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THE MODERN TRAVELING CRANE.*

BY ALEXANDER E. OUTERBRIDGE, JR.

[*Read at the stated meeting of the Institute, held Wednesday, March 15, 1893.*]

Mr. H. R. HEYL, in the chair.

Mr. OUTERBRIDGE spoke as follows:

MR. CHAIRMAN AND GENTLEMEN:

Before proceeding to read the brief paper which I have prepared for this evening, I think, perhaps, that a few words by way of explanation of its motive may not be inappropriate.

It would seem almost superfluous to tell an audience, composed so largely of gentlemen who are engaged in

* A paper read before the Franklin Institute, March 15, 1893, with an introductory address stenographically reported.

mechanical pursuits and familiar with mechanical devices, that the problem which has confronted the modern manufacturer in his effort to produce larger machines of various kinds than heretofore—heavier locomotives, bigger bridges, more powerful war-ships and the thousands of other gigantic structures demanded in this era of mechanical progress—has been, not so much a question of the enlargement of factory buildings, or of increasing the melting capacity of furnaces, or of adding to the number of employés, but it has been mainly a question of obtaining adequate facilities for handling quickly and economically the enormously heavy materials composing such great structures, and I do not think it is an exaggeration to say that the limit of capacity of any establishment for such large work is determined by its facilities for handling its raw material with economy and despatch.

If you are given unlimited time and an unlimited amount of labor you can accomplish great results with exceedingly simple and crude appliances, but the more you try to economize time and labor in the performance of mechanical work, the more intelligence and skill you must crystallize into the forms of auxiliary machinery.

We all know that the simple dropping of water will, in time, wear away the hardest stone, but the little rock drill, which performs its work in a few moments, represents a high degree of mechanical efficiency.

The great pyramid at Gizeh, near Cairo, erected more than 4,000 years ago (or according to the generally accepted chronological records, more than six centuries before the time of Moses) stands to-day the largest structure of any kind ever erected by the hand of man. Composed of huge blocks of hewn stone, covering a space of more than thirteen acres at its base, equivalent to more than four squares of buildings in this city, it rises to a height of more than 450 feet or nearly twice the height of the tallest church spire in Philadelphia. The weight of this great mass has been computed at more than 5,000,000 tons.

Modern writers are fond of pointing to these facts as evidences that the ancients possessed mechanical appliances

for handling heavy materials far surpassing those of the present time, but, until the two important factors of time and of labor are more clearly stated, I think we are justified in withholding our assent to such a broad inference. What did those autocratic rulers of Egypt care whether 100 or 1,000, or 100,000 slaves were employed for a year or a decade or a century in the construction of this great monument? They were building for all time, and had no thought of economy either of time or of labor in the construction.

The Greek historian Herodotus, who visited this pyramid about 400 years before the Christian era, tells us that it was regarded in his day as the most stupendous and most venerable monument of antiquity, and he further states that certain inscriptions on stone tablets recorded the fact that 100,000 men were engaged for thirty years in its construction. I have little doubt that if such a problem should be presented to our modern engineers it could be solved with the expenditure of a fraction of the time and labor represented in this great pyramid.

Coming now to a more modern illustration for the purpose of our comparison, I am reminded of an amusing story related of the late Matthias W. Baldwin, in the early days of his locomotive building in this city. The incident occurred, I believe, about the year 1840. One morning Mr. Baldwin received in his mail an order for twenty locomotives, coupled with the condition that they must be completed and ready for delivery within one year of the date of signing the contract. Mr. Baldwin declared that such a proviso with such a large order was preposterous, and that it would be impossible to complete the contract in the time specified. On looking over the illustrated history of the Baldwin Locomotive Works, I find that the total output for the year 1840 was nine engines, and it was not until thirty years had elapsed that the first 1,000 engines were completed.

The present capacity of the Baldwin Locomotive Works is about 1,000 engines a year. To what shall we attribute this enormous expansion? The enlargement of the buildings and the increased number of employés are important factors, but more men and larger buildings could have been obtained

in former years, while the various modern appliances for expediting work were not then invented, by the aid of which the "impossibilities" of 1840 have become the ordinary realities of to-day.

For a final comparison, I would select an illustration in which you may all have a share. If I should ask any mechanic present to-night to close his eyes for a moment and form a mental picture of the appearance of the machine shop in which he acquired his technical education and to describe its most prominent features, he would probably say something similar to this:

"I see a long, low, dingy building with small windows and little semi-opaque panes of glass admitting feeble illumination; on the floor I see a miscellaneous assortment of machine tools—lathes, planers, boring mills, etc.—crowded together in some places, while elsewhere there are large vacant spaces. I see a number of masts or columns erected at intervals upon the floor, pivoted to foundation plates, and in many instances to the rafters. Attached to these masts are heavy swinging arms, strongly braced, carrying chains and hoisting tackle. A large casting is about to be transported from one end of the shop to the other, the chains are attached, the object is raised a few feet from the floor, it is swung round until the arm intersects the circle of the swing of the neighboring apparatus; it is now deposited upon a vacant space on the floor, again raised, again swung round and re-deposited, and so it is moved step by step until it reaches its final resting-place. Not only is a great deal of time lost in these operations, but valuable floor space also is permanently given up to the hoisting appliances and temporary resting-places for the castings."

Let us now, by the aid of the lantern, visit the new erecting shop of the Baldwin Locomotive Works, and see how this business is accomplished to-day. As we enter the shop, which is nearly a square long and half as broad, we are impressed with its unusual height, its light roof composed largely of glass, its immense windows admitting a flood of light and air. Upon the floor we see scores of locomotives in every stage of manufacture. We perceive that

the entire floor space is occupied by the work in hand and we look in vain for the huge masts and arms, and, if we have not kept in close touch with recent progress in such matters, we may well wonder how these heavy materials are conveniently and expeditiously handled.

Presently we see an immense hook, not unlike the claw of some gigantic mythological bird, descend from above, grasp a cylinder or a boiler or possibly a completed locomotive of the largest size, and sail away with it as readily as though it were a toy. We turn inquiringly to our guide and ask, "What do you call this great mechanical power?"

The answer is contained in the title to my paper for the evening. It is the modern traveling crane.

The old-fashioned cumbersome jib-crane, slow of motion and limited in scope to the swing of its clumsy arm, so long a prominent eye-sore on the floor of every foundry and machine shop, is gradually disappearing, and is being superseded in progressive establishments by the *rapid-transit elevated railway traveling crane*, occupying no floor space and limited in range only by the walls of the building in which it operates. While this modern economical and expeditious method of handling heavy merchandise may still be regarded as a novelty, it has passed the experimental stage and the mechanism has already reached a degree of perfection which leaves little to be desired in respect of speed, safety, simplicity and accuracy of operation. This is the result of much study, costly experiment and practical experience.

The elevated railway traveling crane consists of four essential parts:

(1) The elevated tracks.

(2) The traveling bridge.

(3) The trolley car traversing the bridge and carrying the hoisting mechanism.

(4) The motor or driving mechanism.

The Tracks.—Two independent elevated tracks, with, in some types, parallel toothed racks bolted thereto, are supported by iron columns (or, in the case of a new building specially constructed, built in and supported from the walls).

These tracks run parallel to and close to the walls from one end of the building to the other. The bridge travels upon this runway propelled by positive gearing engaging with the racks, thus insuring perfect alignment under all circumstances.

The Traveling Bridge.—The bridge is constructed of two parallel plate girders extending from rail to rail, spanning in mid-air the breadth of the building. Four large double-flanged steel-tired wheels with steel axles running in bearings are bolted to projections on the girders, a skimming clearance only being permitted between the top of the rail and the bottom of the girders.

Between the girders heavy steel tracks are laid, bolted to their lower inner flanges, upon which a trolley car, carrying the hoisting mechanism, runs back and forth; thus, by the two motions, the longitudinal motion of the bridge and the cross-motion of the trolley every square foot of available space in the building can be covered.

The girders forming the sides of the bridge are securely tied together by angle-iron braces and the bridge is still further stiffened against lateral strains by exterior girders, extending upwards and outwards at a sharp angle from the bottom flanges of the bridge members and bolted to struts or braces extending across the top of the bridge. By this method of construction great rigidity is secured, while the entire space within and beneath the bridge is left unobstructed for the working of the trolley car and machinery.

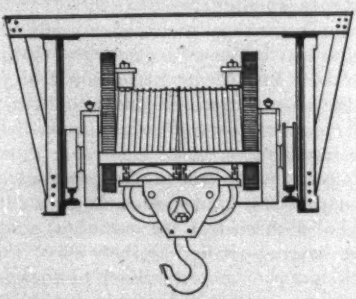
The Trolley Car and Hoisting Apparatus.—The car which travels on the bridge tracks is provided with a grooved drum and depending double chain wound thereon, carrying a forged swivel-hook mounted securely in a hoisting block on ball-bearings, the block being furnished with sheaves through which the chain runs. The friction on the swivel is so reduced by the ball-bearings that it was found in actual trial that a load of fifty tons suspended from the hook could easily be rotated by one man.

The winding of the double chain in the grooves of the drum is always towards the centre, this insures a per-

fectly vertical lift of the load, an advantage always, and a necessary feature in many instances.

The placing of the rails for the trolley on the top of the bridge, as is sometimes done, is open to serious objection on account of the tendency to produce unstable equilibrium of the bridge, or spreading of the girders, and disasters have occurred from the toppling over of the trolley when heavily loaded, due to these causes. It can readily be understood that these defects are eliminated by locating the point of support of the load on the lower inner flanges of the girders, instead of from a trolley on top of the bridge.

The racks meshing with pinions on both ends of the bridge prevent any tendency to mount the rail or to jam



on the runway and permit of high speeds with safety, and, even if an accident should happen to the running gear of the bridge, such as the breaking of an axle, the bridge would merely settle down half an inch and then rest upon the rail.

Retaining clutches automatically hold the load securely from the moment it leaves the floor until it is re-deposited, the chain can never *run* down, but the load must always be *pushed* down by the operator moving a lever.

The operator's post is on a platform or cage supported at a convenient point under the bridge; by simple lever movements he applies the motive-power to drive the bridge along the rails and simultaneously to drive the trolley across the bridge, so that, during the two motions at right angles, the

hook depending from the chain travels in the resultant diagonal direction until it is vertically over the object to be hoisted. A simple application of power revolves the drum lowering the chain, and when the object is attached a like delicate touch of the lever in the opposite direction causes the drum to revolve in the opposite direction, winding up the chain and lifting the object to the desired height. The bridge and the trolley are again started in their respective longitudinal and cross movements, the suspended object traveling in a straight line—the resultant of the two directions—from its starting point towards its destination, until vertically over the exact spot where it is to be deposited when it is a simple matter to lower and adjust it in place. The speed of all of these movements is under absolute control of the operator and the precision of adjustment where delicacy of movement is required, as in the setting of cores, closing of flasks, etc., is remarkable both for its perfection and for the ease with which the operation is performed. These movements may be, and frequently are, directed from below by the finger of the foreman.

The Motive-power.—Various motive-powers are applicable to operate a traveling crane; such as (1) an independent engine and boiler carried on the crane; (2) a square shaft, with tumbler bearings, bolted to the wall of the building; (3) an electric motor or motors. Each of these methods of driving the crane possesses individual peculiarities, and each offers particular advantages for special classes of work and convenient adaptation to peculiar environments.

The best evidence that these distinctions are understood and appreciated, is furnished by many large establishments, such as the Baldwin Locomotive Works, where all of these types, of recent construction, may be seen in the different departments, ranging from lilliputian cranes of five or ten tons capacity adapted to quickly shifting a cylinder, or other portion of an engine, from place to place in its progress from the condition of a rough casting in the foundry to a finished piece in the erecting shop, to the 100-ton electric giant which picks up a completed "Mogul" or "Decapod" engine of the largest size, carrying it swiftly over the heads

of the workmen and depositing it gently on a railway siding near the exit.

While we have thus shown that there are various methods applicable to driving the traveling cranes and in daily use for that purpose, many persons regard the electric current as, *par excellence*, the modern method, and, in accordance with the demand thus created, large electric traveling cranes, having two trolleys on the bridge and five independent motors, have been constructed and are now in operation. A speed of travel on the run-way of 500 feet per minute is attained and a correspondingly quick traverse of the bridge by the trolley. These may be regarded as "lightning express" traveling cranes. The rate of travel or of hoisting is perfectly controllable from that of a snail's pace to the maximum speed, and the limit of speed is mainly a question of expenditure of power.

As a rule, a slow motion is required when the crane is hoisting and transporting heavy weights but the more rapidly the crane can travel from a locality in the building where its work is completed to another where its help is needed, and the more rapidly it can perform the preliminary operations of attaching chains to the object to be lifted (which tedious work may be said to occupy usually about nine-tenths of time during working hours) the more efficient the appliance becomes.

The method of operating a traveling crane by electricity forms the most novel type, and yet so rapid has been the evolution, that already several sub-types are included under this general head. When a single motor is carried on the cage the clutch system, similar to that used with the square shaft mechanism, is employed. In the three-motor or five-motor, or entirely electric crane, the clutches are discarded with the exception of one pair on the trolley.

In the electric system, one or more motors on the bridge or trolley are supplied with current from a dynamo by means of an overhead wire running the length of the building. By touching a few simple levers, or hand wheels, the wheels of the bridge are caused to revolve, the trolley car itself is caused to travel back and forth on its cross tracks,

and the grooved drum carrying the chain and hook is caused to rotate, raising or lowering the hook, all of these motions being performed either at the same time or separately, in the same direction or in opposite directions, at the same speed or at different speeds, fast or slow, without confusion, by one man of ordinary intelligence. The operators are usually chosen from the ranks of unskilled labor, and are soon taught the simple movements. The levers are so arranged that the necessary as well as natural movements of the operator are in the direction he wishes the object to go, thus relieving him of embarrassment or uncertainty.

While this paper is designed to afford a general, or popular, yet accurate, description of the modern elevated railway traveling crane, and is sufficiently broad in its scope to cover the fundamental principles upon which all such cranes are constructed, we desire to point out in conclusion a few of the advantageous features which have been briefly alluded to *en passant*, characterizing the cranes made by William Sellers & Co., Incorporated, on which are lavished the results of indefatigable experiment, aided by extended experience in their shops, and in the manufacture and sale of cranes, covering a period of many years.

SPECIAL FEATURES OF THE SELLERS' TRAVELING CRANE.

Safety.—This is a factor of first importance in a machine designed to transport constantly enormously bulky and heavy materials over the heads of workmen, and has formed the key-note to the design of every part of the structure, for example:

(1) The plate girders forming the bridge not only have inherently an immense reserve factor of safety, but they are also tied together and strengthened by the angle-iron lattice girders on top, and by the external bracing extending from the bottom flanges to struts across the top in a manner entirely original and affording a degree of stiffness unattained heretofore. Furthermore, the maintenance of true alignment and prevention of twisting or jamming by means of the racks and gearing at each end of the bridge relieve

the girders of undue lateral strains and are peculiar to this crane.

(2) Double-flanged wheels with steel tires accurately turned to fit the head of the rail are substituted for cast-iron wheels usually employed for this purpose.

(3) Flat friction-clutches with broad bearing surfaces of positive action are substituted for conical clutches usually employed and of uncertain efficiency.

(4) Automatic support of the load at all times, requiring the use of power by the operator to release the tenacious grip of the clutches and push the suspended object down.

(5) The method of supporting the ends of the girders above the rails with a skimming clearance only, so that in case of accident to the running gear the bridge merely settles upon the rail.

(6) The placing of the trolley car between the girders, instead of on top of the bridge as is customary, contributes to the stability of the entire structure and is an evidence of the careful way in which correct principles have been elucidated and applied to all details. These are but samples of the numerous safety appliances.

Speed.—The ability to reach the load to be moved in the shortest possible time, whereby the preliminary operations of getting ready to lift are materially hastened, combined with the slow and steady pull, free from jar and susceptible of the most delicate adjustment, meets every desideratum.

Economy.—The location of all working parts upon or over the cage, within easy reach and sight, facilitating oiling, tightening of nuts, etc., by the attendant when not operating the levers; the ease with which parts may be removed for repairs, together with the ample proportions of each individual piece in its proper relation to the whole, all tend to minimize the cost of maintenance, while the economy of power in operation has been studied with equal care with the view to make this type of crane *the criterion* by which the merits of all other forms must be judged.

The traveling crane recently constructed at these works

for the Columbian Exposition is an all-electric crane. The bridge has a span of 76 feet and the runway is will be 1,400 feet long ; there are two trolleys on the bridge, with a lifting capacity of ten tons each.

The bridge is provided with an observation platform running its entire length, and upon this platform several hundred observers can be carried from end to end of the machinery building over the exhibits and far above the heads of pedestrians. The platform which carries the passengers does not interfere with the hoisting mechanism, so that this crane may be employed to hoist and transport goods and passengers at the same time, or alternately, if desired.

Such is a brief glance at the operation and capabilities of the traveling crane in general and of the Sellers' crane in particular. Its adaptability as to size, power and practical usefulness extends between wide limits. Cranes are in operation to-day, which will transport with equal ease a complete locomotive of the largest size or a delicate sand mould without disturbing a grain of the sand.

In the foundry and machine shop it makes the entire floor space available, and it is equally applicable in the stone yards, docks, and indeed wherever heavy materials require to be moved with celerity from place to place. A single operator with a single apparatus exceeds the capabilities of a dozen stationary cranes installed within reach of each other, effecting an enormous saving in time, labor and cost.

Thus, the modern traveling crane may fairly be regarded as one of the great inventions entitled to a high rank among the mechanical achievements of modern times.

FROM MINE TO FURNACE.

BY JOHN BIRKINBINE.
President of the American Institute of Mining Engineers.

[*A lecture delivered before the Franklin Institute, November 14, 1892.*]

The lecturer was introduced by the Secretary of the Institute, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

The mining or quarrying of iron ores, coal and limestone, from the earth; their preparation, handling, transportation, and the smelting of the ores into pig iron, offer the theme for what could be made an instructive story, increasing in interest as we take into consideration the earlier history of coal and ore mining and iron production, and as we note the improvement made in processes, and the advances in quantity and quality produced.

The story of iron production and manufacture is old. You have been told of Tubal Cain in the seventh generation from Adam, being "an instructor of every artificer in iron," and of the use of this metal in the pyramids of Egypt, and in the gates of the city of Babylon, of the ancient book of Job mentioning "bars of iron," "barbed irons," etc. This iron was probably made in the simplest possible manner, the ore being taken from the ground, and converted into wrought iron, with the aid of wood or charcoal in heaps in pits, or in crude furnaces. But we need not go far back to trace developments, for the past half century, or even the last twenty years, show more advancement in this specialty than all the preceding years since iron was first mentioned as a metal. I shall say little concerning iron as a metal, preferring to make this a connecting link between two lectures which I presented in this room, viz: "The Iron Ores of the United States" (delivered five years ago), and "The Development of the Pig Iron Manufacture in the

United States," delivered in February, 1891. The substance of neither of these will be repeated, except to call attention to subsequent developments, and to mention facts necessary to bring these two lectures into a connected story.

I shall not, therefore, consider the mining of ores other than those of iron, nor the production of any metal except the necessary incidental reference to pig iron.

To smelt iron ores a fuel and a flux are necessary, and in this country four fuels are employed, namely, anthracite coal, bituminous coal, coke made from bituminous coal, and charcoal. Coke is by far the most in demand for this purpose, and raw bituminous coal is used to but a limited extent, no record being now kept of the comparatively small portion of pig iron made with it exclusively. Including the output of furnaces using raw bituminous coal, alone, or mixed with coke, with those employing coke alone for this purpose, we find that of all the pig iron produced in the United States, 70·6 per cent. is smelted with coke and bituminous coal.

Coke is also liberally used with anthracite coal in varied proportions in the eastern part of the United States, 18·8 per cent. of the pig iron being made with these mixed fuels, and but 3·7 per cent. of our pig iron output being smelted with anthracite coal alone; the remainder, 6·9 per cent., is produced by the use of charcoal. At present the relative employment of the different fuels ranks in the following order:

Coke, sometimes mixed with raw bituminous coal.
Anthracite and coke mixed.
Charcoal.
Anthracite alone.
Raw bituminous coal.

Limestone is the universal flux used, although different conditions require stone of varying composition, from nearly pure carbonate of lime to a mixture of the carbonates of lime and magnesia, known as dolomite.

The iron ores fed to blast furnaces are also of varying composition; the convenience of these to furnaces, the yield of iron, the proportion of other ingredients which they carry, such as silica, lime, alumina, magnesia, phos-

phorus, sulphur, titanium, manganese, etc., and the expense of mining the ores influencing their use.

It is not within the province of this lecture to discuss the chemical composition of ores, but as the methods of producing different varieties, and the yield of these in iron will necessarily demand attention, a brief summary of the classification adopted is offered.

The iron ores produced in the United States may be divided into four general classes, without particular reference to their geological occurrence, but approaching within narrow limits the practice generally followed in the sale and purchase of iron ores.

(1) *Red Hematite*, all the anhydrous oxides of iron known by various names, such as red hematite, blue hematite, specular, micaceous, fossil, slate iron, martite, flax-seed ore, etc.

(2) *Brown Hematite*, including the varieties of hydrated sesquioxide of iron, variously known as limonite, gœthite, turgite, bog ore, pipe ore, pond ore, grape ore, and also some manganiferous iron ore, and most of the iron ores mined in the Rocky Mountain region for the smelting of argentiferous ores.

(3) *Magnetite*, those ores in which the iron is found chiefly as magnetic oxide: this class also includes some martite mined with the magnetite.

(4) *Carbonates*, those ores which contain a considerable amount of carbonic acid, such as spathic ore, siderite, black band, clay ironstone, etc.

COAL.

The universal use of coal makes the quantity employed for producing pig iron, though aggregating millions of tons, represent but a small percentage of the total output, hence a few facts only need be given of the production, preparation, handling, or utilization of coal. A review of the methods employed in various parts of the country would make a lecture of itself.

Great Britain and the United States are the two principal coal-producing countries in the world, followed by Germany,

France, Austria, Belgium, Russia, Australasia, Canada, Japan, India and Spain, in the order named; these being the only countries which up to date have records of a yearly output of over 1,000,000 tons each.

The United States, occupying second position, produced in the year 1891, 150,500,000 tons of coal, or thirty per cent. of the total coal production of the world, variously estimated as from 500,000,000 to 550,000,000 tons in 1891.

In 1891, Great Britain produced 185,500,000 tons or 30,000,000 tons more than the United States. If, however, a retrospective view of the increase in the coal production in these two countries be taken, it will show that Great Britain's output since 1880 has augmented 38,500,000 tons, while that of the United States, in the same period, shows an increase of 87,000,000 tons, and if this rate be maintained, it is probable that in the near future, the output of the United States will surpass that of Great Britain.

Of the other countries, Germany produced in 1891 94,000,000 tons (of which, approximately, one-fifth was lignite); France and Austria 26,000,000 each—two-thirds of Austria's product being lignite; and Belgium 20,000,000 tons. None of the other countries have yet reached a yearly output of 10,000,000 tons.

In coal mining, Pennsylvania occupies first place among the thirty-one States and Territories (including Alaska), which produce this fuel. According to the Census of 1889, it contributed fifty-eight per cent. of the nation's coal output, and more than one-half of what was credited to this State came from the anthracite coal fields of Eastern Pennsylvania.

As coal is used for so many other purposes, the consumption of this fuel in the production of pig iron can be only approximated. An estimate carefully prepared places the consumption in our blast furnaces in 1891 at 2,000,000 tons of anthracite coal, 12,000,000 tons of bituminous coal, principally converted into coke, and 66,000,000 bushels of charcoal.

It should be borne in mind that when referring later to iron ores, the amounts mentioned are of prepared ore ready for shipment, for the actual exploitation of the various mines

demands a removal of quantities much in excess of those given. The brown hematites, as a rule, are washed to remove clay and foreign matter, and to enrich the ore, and often the amount of such foreign matter removed is four or more times as great as that retained. The carbonate ores must be roasted to remove their carbonic acid, and the roasted ores represent only about half the weight of the raw ores. Roasting is also applied to sulphurous ores, and hand sorting is employed liberally in the Lake Superior region. In addition to this the separation of comminuted ore, either by jigs or by magnetism, produces a ton of concentrated ore from one and one-half to five tons of crude material. It is therefore probable that for the production of over 14,500,000 tons of merchantable ore in 1891, fully 25,000,000 tons of material were removed from the ground.

The quantity of limestone used as a flux for blast furnaces in 1890, as reported to the United States Geological Survey, was approximately 5,500,000 tons, and in 1891 the amount thus used would be about 5,000,000 tons. We therefore have in round numbers 35,500,000 tons of raw material, mined or quarried, and prepared for market, to produce 8,250,000 tons of pig iron, nearly all of which has to be carried a considerable distance to points of consumption. If we allow for unmerchantable material mined and handled, it is probable that we would reach a total exceeding 50,000,000 gross tons annually. No attempt will be made to discuss the amount of labor required to produce, prepare, handle and transport this raw material. A statement of the quantity required is sufficient for present purposes, but some of the features connected with the handling and transportation of these materials will be offered.

IRON ORES.

The United States is at present the largest iron ore producing country in the world, her 1891 output of 14,500,000 gross tons being 1,750,000 tons more than her nearest rival, Great Britain, supplied in that year. Great Britain has in a former year, 1880, produced 18,000,000 tons, while the largest output of the United States was in 1890, when

16,000,000 tons were produced. Great Britain has, however, showed a great falling off in the output of her domestic iron ore mines, while her imports of foreign ores have been growing larger.

Of the other large iron ore producing countries, Germany contributed in 1891 over 10,500,000 tons, Spain approximated 5,000,000 tons, France 3,500,000 tons, Austria and Hungary over 2,000,000 tons, Russia 1,750,000 tons, and Sweden not quite 1,000,000 tons. Iron ores are also largely mined in Algeria, Italy (principally in the island of Elba), Greece, Cuba, China, and in smaller amounts in various other foreign countries.

Great Britain and the United States combined produce fully one-half of the iron ore mined in the world.

In the year 1887, when the lecture on iron ore was presented, this country was estimated as producing nearly 12,000,000 tons of iron ore; in 1890, the output of our domestic mines, as above stated, was over 16,000,000 tons; and although there was a marked decline in iron production and allied industries last year, the mining of over 14,500,000 tons of iron ore in 1891 shows an increase in five years of over twenty per cent.

There are no authentic records of the output of the different kinds of iron ores in the various States in 1887, or, in fact, for any years except 1880, 1889, 1890 and 1891, the first two being Census figures, while the last two were prepared for the division of mineral statistics and technology of the United States Geological Survey.

[The lecturer here exhibited a diagram, showing the amounts of the different kinds of iron ore produced in the various States in the four years above-mentioned. Only those States which mined over 100,000 tons of iron ore were shown, the smaller producers being grouped together under the head of "other States." Solid cross-section lines indicated red hematite ores; dotted cross-section lines, brown hematite ores; black blocks, magnetite, and dotted blocks, carbonate ores. The States were placed in the order of their precedence as total producers in the different years, *i. e.*, the State holding first rank was placed at the bottom of the

column, and the second immediately above it, etc. The same scale was used in each of the columns, and the same tonnage in one year occupied equal spaces in any of the other years.]

The diagram shows a decided advance in the use of hematites, a slight decline in the proportionate amount of magnetites, and a very great falling off in the quantity of carbonates used in the decade.

In the year 1880, thirty-one and one-half per cent. of the total iron ore product of the country was red hematite; in 1889, it had risen to sixty-two and one-third; in 1890, to sixty-five and two-thirds per cent., falling off slightly in 1891, when the percentage of the total was but sixty-four.

The brown hematites constituted twenty-seven per cent. of the total iron ore mined in the United States in 1880, the proportion declining in 1889 to seventeen and one-third per cent., and in 1890 to only sixteen per cent., but advancing in 1891 to nineteen per cent. of the total

Thirty per cent. of the country's iron ore output in 1880 was of the magnetite variety; but in 1889, less than seventeen and one-third per cent.; in 1890, sixteen per cent., and in 1891, less than sixteen per cent. of the total was of this character of iron ore.

The percentages of carbonate ore used show a constant decline from eleven and one-half per cent. in 1880 to three per cent. in 1889, two and one-third per cent. in 1890, and one and one-third per cent. of the total product for the country in 1891.

While the above indicates a decline in the proportion of all the ores used except red hematite, a comparison of the outputs for 1880 and 1891 shows a material decrease in quantity in carbonates only; the magnetites and hematites having an augmented production.

The amounts of the different kinds of iron ore produced in 1891 were as follows: 9,327,398 tons of red hematite, 2,757,564 gross tons of brown hematite, 2,317,108 gross tons of magnetite, and 189,108 tons of carbonate ore, making a total iron ore product for the year of 14,591,178 gross tons. Of this total, Michigan contributed over 6,000,000 tons;

Alabama nearly 2,000,000; Pennsylvania over 1,250,000; New York, 1,000,000, and Minnesota nearly 1,000,000 tons; the total of these five States aggregating nearly 11,500,000 tons, or nearly seventy-eight per cent. of the country's output of domestic ores for 1891. This total will exceed 11,500,000 tons by adding scattered operations from which no returns were received. In addition to the American ores mined, nearly 1,000,000 tons of foreign iron ores were imported into the country. There was also considerable amounts of mill cinder, blue billy, franklinite slag, etc., used; but in tracing the ore from mine to furnace, these may be considered as being offset by the amount of iron ore which is used as fix in puddling and heating furnaces, as flux in silver smelting, and in the manufacture of paint, etc.

The relative rank of States as producers in the various years offers interesting suggestions as to the changes in their percentages of the iron ore output, and in the table below is given the total output of iron ores in 1880, 1889, 1890 and 1891, with the percentages of this total which each State produced:

	1880 *Per Cent.*	*1889* *Per Cent.*	*1890* *Per Cent.*	*1891* *Per Cent.*
Pennsylvania,	27·41	10·75	8·50	8·72
New Jersey,	9·50	2 86	3·09	3·60
New York,	15·83	8·59	7·82	6·97
Michigan,	23·04	40·34	44·54	41·99
Wisconsin.	0·52	5·77	5·92	4·04
Minnesota,	—	5·95	5·56	6·48
Alabama,	2·40	10·82	11·83	13·62
Virginia,	2·29	3·43	3·39	4·52
Tennessee,	1·31	3 26	2·90	3·73
Georgia,	1·15	1·71	1·52	1·72
Missouri,	4·84	1·83	1·13	0·73
Colorado,	—	0 75	0·71	0·76
Total output in gross tons,	7,120,362	14.518,041	16,036,043	14.591,178

All of the iron ore obtained from Minnesota in 1891, over seven-eighths of that from Michigan, nine-tenths of that from Wisconsin, three-fourths of that from Alabama and Tennessee, and nearly all of that from Missouri, was of the red hematite variety. Virginia is the largest producer of brown hematites (nearly all of its product being of that char-

acter of ore), followed in order by Alabama, Michigan, Pennsylvania, Georgia and Tennessee, as important contributors, and this is the only class of ore mined in the New England States, Texas, Oregon and some other States. Three-fourths of the total output of New York, over one-half the Pennsylvania product, and practically all of that obtained from New Jersey was magnetite, these three States producing seven-eighths of the total of this character of ore mined. Michigan follows New Jersey, then follow New Mexico and North Carolina as producers of magnetite. The State of Ohio was the only large producer of carbonate ore in 1891, although smaller amounts were obtained in New York, Pennsylvania, Kentucky and Maryland.

The product according to States does not properly represent the development of the iron ore industry, as well as that of certain prominent districts, and a diagram is presented to show the authentic record of such of the more prominent districts as could be obtained for twenty years past, or less. The rapid advance of the Lake Superior districts illustrates the growing favor of the blast furnace managers to the use of the rich red hematite ores. The combined lake and all rail shipments of the four districts will, in 1892, slightly exceed those of 1890. In this representation the importations of foreign ores (ninety-five per cent. of which were received at the ports of Philadelphia and Baltimore) were inserted for the purpose of comparison.

Even the product by districts does not truly show the remarkable extent which the development has reached in certain localities for nine mines in the Marquette Range, three in the Menominee, four in the Gogebic Range, and two in the Vermilion Range, have since their opening contributed from 1,000,000 to 6,000,000 tons each. The mines at Port Henry, N. Y., have yielded to date about 10,500,000 tons of iron ore, but no single deposit has equalled the record of the Cornwall ore hills in Pennsylvania, exceeding 12,000,000 tons, which have been obtained from this deposit, which has for a number of years averaged a greater output per annum than any other single mining enterprise, reaching

its maximum of 769,000 tons in 1889. On three occasions, however, this maximum has been exceeded by the annual output of one of the Lake Superior mining companies.*

In the year 1891 there were but four mining enterprises in the country, the product of which exceeded 500,000 tons, although an equal number closely approximated this output. Two of these four great producers were located in Michigan, one in Minnesota and one in Pennsylvania. In addition there were in the Marquette Range three, in the Gogebic Range two, in the Menominee Range one, in Minnesota one, in New York two, and in Alabama three mining operations whose output in 1891 was between 200,000 and 500,000 tons.

Although iron ore in this country was first found in North Carolina, and iron was first produced in Virginia, the successful pioneer enterprise was in Massachusetts, in the year 1645. Most of the ore used was bog or pond ore, and one plant in Canada is still operated chiefly on this class of brown hematite ore. The following illustrates the way in which pond ores were obtained in Massachusetts in the year 1794:† "Vast quantities of iron, both cast and wrought, have been made in this part of the country for more than a hundred years past; but it was chiefly out of bog ore, until that kind was much exhausted in these parts. About the year 1747 it was discovered that there was an iron mine in the bottom of our great pond at Assowamset; and after some years it became the main ore that was used in the town, both at furnaces and forges, and much of it has been carried into the neighboring places for the same purpose. Men go out with boats, and make use of instruments much like those with which oysters are taken, to get up the ore from the bottom of the pond. I am told that for a number of years a man would take up and bring to shore two tons of it in a day, but now it is so much exhausted that half a ton is reckoned a good day's work for one man. But in an

* In 1892 three mining operations exceeded the output of the Cornwall ore hills.

† *Vide Volume of Manufactures; Tenth Census*, p. 798.

adjacent pond it is now plenty, where the water is twenty feet deep, and much is taken from that depth, as well as from shoaler water. It has also been plenty in a pond in the town of Carver, where they have a furnace upon the stream which runs from it. The quantity of this treasure, which hath been taken out of the bottom of clear ponds, is said to have been sometimes as much as 500 tons in a year." The average price of these pond ores was about $6 per ton, delivered at the furnace.

Nearly all of the iron ore mined in the earlier history of the iron industry was of the bog or pond varieties, and it was not until the commencement of the eighteenth century that any of the magnetic ores of New Jersey were utilized. The Dickerson Mine, which lately closed down, was one of the first mines of this character of ore opened, being located in 1716. The ore was often carried to the iron works in leather bags on pack horses.

Blast furnaces increasing in number and size required larger supplies of iron ore, flux and fuel, and to meet this it was necessary to employ other methods than those of dragging for iron. At first most of the mines were worked "open cut," but as the demands increased it became necessary to work underground so as to avoid heavy stripping, and danger from slides. There are, however, numerous open cut mines wrought at present and some large underground operations are being transformed into open cuts. The pick and the shovel, while still used, are largely supplemented by the steam, air or electric drills, and in some cases by steam shovels. High explosives have displaced much of the ordinary powder, and the wagons or carts drawn to the surface by horses or mules are to a great extent superseded by hoisting appliances operated by steam-power or by compressed air, and in place of ore carried in wagons or on pack saddles, we have the rapid and cheap transportation by the various steam railroads to supplement that by water. The harder red specular ores, which were first mined in Michigan in 1847, owing to low water transportation rates and the high percentage of iron they contain, came rapidly into favor, and it may be of interest to draw a com-

parison between the pond ore exploitation described above and one of the modern iron ore mines of the Lake Superior district.

At the Chapin Mine at Iron Mountain, Mich., the ore is taken from four shafts, ranging from 300 to over 600 feet in depth, and from an open pit of over an acre in area. The fourth shaft was sunk through a stratum of quicksand, and in order to pass this, a circle of iron pipes was driven and connected with a refrigerating machine. This reduced the temperature of the contents of the pipe to about zero, freezing the quicksand, and, keeping it frozen, this was then drilled and blasted like rock. The machinery of the mine is run chiefly by means of compressed air, although there is ample boiler capacity to operate the entire plant in case of accident to the compressor plant. This compressed air is carried a distance of three miles in wrought-iron pipe 24 inches in diameter. The Quinnesec Falls furnish, under a head of about 52 feet, the water to three 48-inch and one 54-inch turbine. There are three pairs of 32-inch diameter and 60-inch stroke, and one pair of 36-inch diameter and 60-inch stroke compressors. This compressed air is the motive-power for the hoisting plant and also for more than 100 power drills. The number of employés varies from 1,800 to nearly 2,000. The ore is found in four large lenses, and is broken down by means of power drills and high explosives, loaded on mine cars, taken to the shafts, hoisted to the surface, where a cable conveys it to the trestle, on which the cars are automatically dumped into railroad cars or taken to the stock pile, from which the ore is afterward loaded on railroad cars by means of a steam shovel. By this means a twenty-ton car has been loaded in four minutes. As much as 2,700 tons of ore have been hoisted from one shaft in twenty-four hours, and in one year over 700,000 tons were mined.

[*To be continued.*]

PHILADELPHIA'S SHARE IN THE DEVELOPMENT OF PHOTOGRAPHY.

By Mr. Julius F. Sachse.

[*A lecture delivered before the Franklin Institute, December 16, 1892.*]

The lecturer was introduced by the Secretary of the Institute and spoke as follows:

Mr. President, Members of the Franklin Institute, Ladies and Gentlemen:

It is well-known to most persons that photography is, with the exception of the art of printing, the most widely disseminated art-science throughout the world.

Within a few decades, modern photography has penetrated into every quarter of the known world; and the vast space within the limits of the lately explored ice cap of Greenland to the tropical jungles of equatorial Africa, has been conquered and brought into subjection in the interest of general information by the modern dry-plate and the perfected lenses of the present day.

It is but a little over half a century, or, to be exact, just fifty-three years ago, when the first account of Daguerre's process reached America by the slow and uncertain methods of communication of the day. And when the news arrived it was published, only to be received by nearly everyone with suspicion and ridicule; and the whole matter was set down by scientist and scholar as another grand hoax, similar to the one sprung upon the scientific world a few years before in connection with Herschel's great telescope.

However, the doubt and uncertainty were soon dispelled by a member of this institution, after which the development of the process was rapid and steady.

Although it is but a question of half a century, few persons at the present day are aware that photographic portraiture is a Philadelphia invention, or how great is Phila-

delphia's share in the development of photography, and that the present perfect state of universal photography was brought about mainly by Philadelphia investigators and experimenters, their efforts being fostered by two of Philadelphia's scientific institutions; the first of these, the American Philosophical Society, the oldest and then most active and important scientific society in America; the other one, though in its comparative infancy, lacked none of the vigor of its more mature rival, and now after an active life of almost three-fourths of a century stands as an acknowledged scientific centre in the world. I allude to the Franklin Institute.

Daguerre, after the first promulgation of his process, and the vote of a pension by the French Chamber of Deputies, never did anything towards the improvement of his invention. It was left to the experiments of others to give the process a practical and commercial value.

To a Philadelphia scientist is due the improvement to Daguerre's process as originally promulgated, which made its universal application possible, and in reality forms the basis of the whole photographic structure of to-day. I have reference to the application and use of bromine as an accelerator by Dr. Paul Beck Goddard, of Philadelphia.

In connection with this subject, I will advance the following claims for Philadelphia in the development of photography, viz:

(1) That Joseph Saxton, of Philadelphia, made the first heliograph in America, October 16, 1839.

(2) That Robert Cornelius, of Philadelphia, and a member of the Franklin Institute, obtained the first picture of a human face ever taken by Daguerre's process, November, 1839.

(3) That to Dr. Paul Beck Goddard, of the faculty of the University of Pennsylvania in Philadelphia, belongs the honor of the discovery of bromine as an accelerator, December, 1839.

(4) That Dr. Paul Beck Goddard, of Philadelphia, was the first person in the world to obtain an instantaneous picture by heliography, December, 1839.

(5) That William G. Mason, of Philadelphia, obtained the first perfect picture in the camera by aid of artificial light, December, 1839.

(6) That the first portrait studio in America, or more strictly in the world, was opened in Philadelphia, February, 1840, by Robert Cornelius, at the northeast corner of Eighth Street and Lodge Alley.

(7) That the first heliograph ever entered for exhibition was one by Dr. Joseph E. Parker at the tenth exhibition of the Franklin Institute, held in October, 1840, at the old Masonic Hall, in Philadelphia.

(8) That Joseph Saxton, of Philadelphia, in 1841, produced the first photo-mechanical reproduction for use with printer's ink, which combined in its production the daguerreotype, electrotype and a mechanical process.

(9) That the first successful attempts at interior photography were made by Dr. Paul Beck Goddard, January, 1840, at the Academy of Natural Sciences, at the southeast corner of Twelfth and Sansom Streets. The originals are still in existence.

I will further state the daguerrean portraiture had actually ceased to be a novelty in Philadelphia long before the process was even introduced elsewhere in this country, or was practised in Europe.

To establish this fact, it is but necessary to refer to the *Public Ledger*, of October 12, 1840, where in the account of the tenth exhibition of the Franklin Institute, then in progress, it states:

"Throughout the room are various specimens of the daguerreotype. They consist chiefly of miniatures."

The first authentic account of Daguerre's process to reach America was a letter written in Paris and sent to Alexander D. Bache, a member of the Philosophical Society and of this Institute. This letter, which embodied the whole secret, then first made public, was published in the *United States Gazette*, September 25, 1839, with an introduction in which it was stated that some steps of the process are not explicable by known laws. This account set forth the crude process of Daguerre, as first publicly announced to the Chamber of

Deputies, in Paris, August 19, 1839. It was republished in the *Journal of the Franklin Institute*, for September, 1839, without a word of notice or comment. This was followed in the next *Journal* (October, 1839, p. 287), with an account from *Galignani* of three street scenes in Paris, taken from Daguerre's atelier, which were exhibited before the Chamber of Deputies at a meeting subsequent to the one held August 19th.

Notwithstanding these repeated notices of the heliographic process, no action whatever was taken upon the subject by any scientific institutions, the published accounts thus far being looked upon as unworthy of serious consideration.

A few weeks later, however, a more detailed account reached America; this was from an eye-witness, who was a special correspondent of the *New York Star*. It was published October 14, 1839, and gave an account of the public demonstration given by Daguerre on the 17th of September at the Grand Hotel, on the Quay d' Orsay.

So skeptical were the Parisians of Daguerre's claims, and so great was the popular opposition to the grant made by the deputies to the inventor, that to silence public clamor the Minister of the Interior ordered Daguerre to give three public demonstrations of his process so that the interested public might judge whether the deputies were justified in pensioning Daguerre for the disclosure of his process.

This account was reprinted in the *American Daily Advertiser*, October 16, 1839. So crude was Daguerre's method, as shown by this account, that the time occupied to produce this single picture was one hour and twelve minutes.

Among those whose notice was attracted to the publication of Daguerre's process was one Joseph Saxton, an attaché of the United States Mint in this city, a man of culture and great scientific accomplishments. When Saxton read this account as published, it seemed so clear and feasible, that he at once concluded to try the process according to the directions set forth in the newspaper.

A cigar-box was improvised as a camera, while an ordi-

nary burning glass, consisting of a convex lens, was fixed in one end an dmade to do duty as an objective. A pasteboard seidlitz-powder box, containing some flakes of dry iodine, and a cut-out in the lid somewhat smaller than the plate answered the purposes of a coating box. For a mercury bath, the ingenious experimenter mortised a block of hard wood, attaching underneath a globular bottom of sheet iron, so as to hold the quicksilver and allow the application of a spirit lamp beneath. A piece of polished silver

Fac-simile of the first daguerreotype (heliograph) made in America, by Joseph Saxton from window of Mint, October, 1830.

ribbon, such as coin blanks are cut from, served in lieu of the copper plates.

When all these preparations were completed, the ingenious Saxton set his apparatus on the window-sill of one of the second story north windows of the Mint, and pointed it northeastwardly toward the sunlit buildings beyond. After the exposure, the instructions in the newspaper were followed to the letter amidst the ridicule of the other attachés who were present, but, to the great surprise of the latter, and the joy of the experimenter, the attempt resulted in a perfect picture. There, permanently impressed upon the silver plate, was the picture of the old Philadelphia High

School and the State Arsenal, which then stood upon the site.

Joseph Saxton had proved the truthfulness of the published account of Daguerre's invention, and had made the first heliograph in America. On the next day, Saxton succeeded in making several other pictures of different buildings, all of which were taken from the same window.

Fac-simile of what is believed to be the first portrait ever made by the daguerreotype process. Taken by Robert Cornelius, in Philadelphia, November, 1839.

To Robert Cornelius, of Philadelphia, is due the honor of having produced the first successful portrait of any living person by the Daguerre process. This was accomplished in the yard back of his store and residence, (old) 176 Chestnut Street, above Seventh (now number 710), in Philadelphia.

How Robert Cornelius, who was a lamp-maker and a metal-worker, became interested in Daguerre's invention, is best told in his own words to the speaker, viz:

"Mr. Saxton, who was then connected with the United States Mint, had the opportunity of receiving an early notice of the manner in which Daguerre was operating. He soon produced a picture from the second story of the Mint—a view of chimneys and tops of houses. He was anxious to continue the experiment and called upon me, and showed his experiment, explained to me the manner of doing it, and desired me to prepare some plated metal to experiment with. With pleasure I complied with his request. It was our business to make a great variety of articles of plated metal. Very soon afterwards, I made in the factory a tin box, and bought from McAllister, 48 Chestnut Street, a lens about two inches in diameter, such as was used for opera purposes. With these instruments I made the first likeness of myself and another one of some of my children, in the open yard of my dwelling, sunlight bright upon us, and I am fully of the impression that I was the first to obtain a likeness of the human face."

In a subsequent communication in reference to this picture, Mr. Cornelius writes, viz:

"You will notice the figure is not in the centre of the plate. The reason for it is, I was alone, and ran in front of the camera after preparing it for the picture, and could not know until the picture was taken that I was not in the centre. It required some minutes with iodine to produce the effect."

This achievement of Robert Cornelius, a member of this society, is all the greater when it is considered that at that time, in Europe, it was considered impossible to apply the Daguerrean process to the production of portraits; for, with the chemicals and apparatus there employed, no picture could be taken in less than about a quarter of an hour, and as the correctness of a portrait produced by this art depends upon perfect immobility during the whole sitting, the mere idea of such an application of photography was looked upon as altogether absurd.

This statement will be found in the *Franklin Institute Journal*, vol. x, p. 50.

Unfortunately the exact date of this successful experiment at portraiture has not come down to us, nor is Mr. Cornelius able to recall it with certainty. That it was not long after Saxton s experiment is, however, proven by the fact that one of the pictures was shown by Robert Patterson, a director of the Mint at the regular stated meeting of the American Philosophical Society, December 6, 1839, and the fact is so recorded upon the minutes (*Proc. A. P. S.*, vol. i, p. 155).

It was not until a month later that the first French daguerreotype reached America. This was obtained in Paris by Mr. Henry Seybert and sent to the Philosophical Society in Philadelphia, and was shown at the regular meeting, January 3, 1840 (*Proc. A. P. S.*, vol. i, p. 169).

A comparison with Saxton's early efforts showed that they were equal, if not superior, to the French specimen, while Cornelius' and Goddard's efforts were far in advance of the French production.

The month of December, 1839, was destined to prove a memorable one in the development of the heliographic art.

It was during this month that the most important improvement was made upon Daguerre's process. This was the application of bromine as an accelerator, by Dr. Paul Beck Goddard, of Philadelphia. It was this discovery which solved the question of time exposure, perfecting Daguerre's process and thereby making possible its universal application in the various arts and sciences.

The proof of Dr. Goddard's claim to priority in the use of bromine is to be found in the *Proceedings of the American Philosophical Society*, vol. iii, p. 180.

The experiments of Dr. Goddard, in December, 1839, resulted in the production of a perfect specimen by the use of bromine, and was subsequently shown at the Philosophical Society. It was during this series of experiments with bromine that Dr. Goddard succeeded in obtaining several good views instantaneously in the open air, which were the first instantaneous pictures ever made by any heliographic process.

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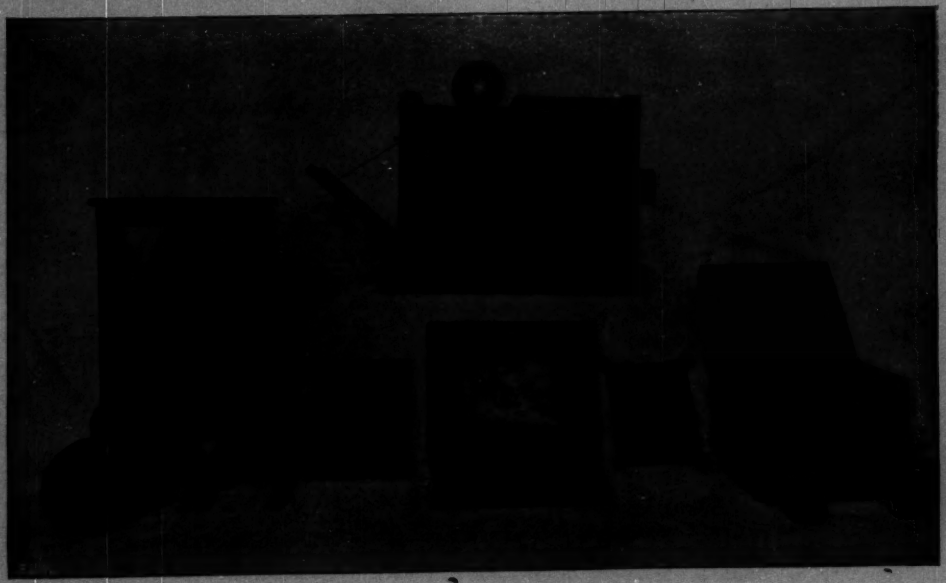

STUDIO OUTFIT OF DR. PAUL BECK GODDARD, PHILADELPHIA, 1840.

Lens and Shutter.
Camera with body extended, showing mirror set for focussing.
Fuming box ready for use, with glass to view process during development.
Plate holder, with original coated plate open for exposure.
Coating box, with rake to distribute chemicals on tray.
Iron Mercury bath.
Brass spirit lamp.
Tray chemicals used in coating plates.
Diffuser for Vapor.
Mercury bottle.
Iodine bottle.

The eleventh annual exhibition of the Franklin Institute, held at Chinese Museum, N. E. corner Ninth and Sansom Streets, October, 1842. Daguerreotype by Dr. Paul Beck Goddard. Negative from original by Julius F. Sachse.

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The First Studio.—Spurred on by his success in experimental portraiture, Robert Cornelius, together with Dr. Goddard, devoted considerable time to heliographic experiments, and the application of the process to portraiture. These progressed so satisfactorily that early in the year 1840 Mr. Cornelius secured the second story room in the building at the northeast corner of Eighth Street and Lodge Alley (now Jayne Street) above Chestnut. This was arranged exclusively for daguerrean portraiture, thus making it the first heliographic studio in the world.

The method employed to concentrate light upon the sitter consisted in a series of reflectors, set at different angles, together with the use of blue glass to screen the sitter. The time for a sitting averaged about one minute. It is an interesting fact that the first apparatus, such as the camera, plates, mats, coating boxes, etc., were all made by Mr. Cornelius personally. The lenses he obtained from McAllister, the Philadelphia optician.

In connection with this subject I have here a copy of the first successful studio picture, the father of the speaker, taken by Mr. Cornelius in his new establishment.

The original is a representative specimen of his skill and proficiency, and its perfect condition at the present day attests the permanency of his early efforts.

Considerable success attended Mr. Cornelius, a leading feature being an increase in the size of the image. Thus on March 6, 1840, we again find a notice of his progress chronicled in the *Proceedings of the Am. Philosophical Society.*

"Dr. Patterson exhibited some specimens of the heliographic art (daguerreotype) of a large size, executed by Mr. Robert Cornelius, of Philadelphia, and stated to the society that Mr. Cornelius had succeeded in obtaining beautiful representations upon highly-polished silver plate." (*Proc. A. P. S.*, vol. i, p. 181.)

Mr. Cornelius' enterprise attracted much attention among the wealthy and scientific classes, and brought many sitters to the establishment.

An interesting item for the professional photographer of to-day who furnishes a dozen cabinets for $1, or who turns

out thirty-six tintypes for a quarter, is, that so great was the rush for the daguerrean miniatures, as they were called, that prospective sitters had to be "booked" a week ahead, at $5 for each sitting. Each received his day and hour, subject, of course, to sunshine. No sittings were attempted in cloudy weather.

About a year after the "atelier," at Eighth and Lodge Alley, was established, Mr. Cornelius removed his estab-

Fac-simile of the first successful studio portrait, made by Robert Cornelius, 1840.

lishment to larger quarters on the south side of Market Street. His announcement in the *Public Ledger*, of July 1, 1841, reads, viz:

"*Daguerreotype Miniatures.*—R. Cornelius respectfully announces that he has resumed the taking of daguerreotype miniatures, and invites the public to call at his rooms, No. 270 Market Street" [now 810], "where specimens of the art can be seen. The recent improvements are such that minia

tures can be made in the shade and without regard to the state of the weather."

The last positive record we have relating to Cornelius as a professional heliographer is the entry upon the minutes of the stated meeting of the American Philosophical Society April 15, 1842, stating:

"Mr. G. W. Smith presented some daguerreotype portraits made by Mr. Cornelius by an improved process, an important part of which was the greater polish given to the plate, and the absence of cross lines."

The splendid results obtained by Cornelius, Goddard and others in Philadelphia, gave the art-science that impetus which has since placed it among the indispensable arts of the present day.

Another application of the heliographic art, which has now reached enormous proportions, viz: that of mechanical reproductions for printing purposes, is also due to Philadelphia scientists. The first photo-mechanical reproduction ever made was one by Joseph Saxton, to illustrate a Philadelphia book in the year 1841, viz: Eckfelt and DuBois' *Manual of Gold and Silver Coins.* It is a view of the Mint, and appears on the title-page. We reproduce a copy herewith.

Commenting upon it, the authors state:

"To obtain the vignette of the Mint (which is on the title-page), as there was no medallion to rule from, it was required to go back to the original, and this necessarily brought into play another brilliant invention of modern times, the daguerreotype. A picture of this edifice was taken with this instrument by Mr. Saxton, from which a copy was engraved in soft metal by Mr. Gobrecht; from this copy a counterpart was obtained in copper by the electrotype, and therefrom the engraving was effected. This view is therefore commended to the reader, not only as a faithful transcript of the original, but as combining in its production three discoveries which adorn the present age, the daguerreotype, electrotype and machine engraving."*

* *Manual of Gold and Silver Coins*, Philadelphia, 1842, p. 189.

The first published record of interior photography appears in a notice of a series of views taken of the thirteenth exhibition, held October, 1844, at the Chinese Museum. For some reason the Institute Committee failed to take any notice of these views; not so, however, with the reporter of the *Ledger*, wide-awake as the news-gatherer of the present day. A note was made of the novelty and on October 25, 1844, appears the following notice, viz:

"In the southwest corner of the gallery, W. & F. Langenheim have their daguerreotype apparatus, with a number of excellent specimens of their work. They have several daguerreotype views of the exhibition, taken from favorable points, which look very well, and are, of course, accurate, but unavoidably left-handed."

As early as the next year, 1845, the Messrs. Langenheim made some excellent instantaneous views of America's greatest natural wonder, Niagara Falls; specimens which for beauty of finish and execution have never been surpassed. Copies of this effort were sent to Daguerre, to the President of the United States, and to various crowned heads of Europe.

In return Daguerre sent the following characteristic note, one of the few written by him in the first person and signed by his name:

À Monsieur le Consul de France à Philadelphie.

MONSIEUR:—I profit with great satisfaction by the return of Mr. Martin to America to thank you for your kindness in sending me the charming view of Niagara, which is due to the amiable attention of Messrs. Langenheim. Besides the merit of these proofs of execution they have also the merit to represent one of the wonders of the known world.

I beg of you sir, to be my interpreter with the Messrs. Langenheim by tendering them all my gratitude.

I repeat to you sir, my thanks, and I pray you to accept this expression of my regards.

DAGUERRE.

Bry-sur-Marne, le 30 Juin, 1846.

The King of Saxony complimented the Philadelphia daguerreotypists by sending a note of thanks and a medal.

Frederick of Prussia accompanied his thanks by the great gold medal for art.

The King of Würtemburg also sent a gold medal.

Queen Victoria through Lord Aberdeen, sent the following note:

> I have now the pleasure to acquaint you, that, although it is a general rule with her Majesty not to receive presents from any quarter, her Majesty has been graciously pleased to accept this view of the falls of Niagara and express her admiration at the great skill with which it has been taken.
>
> [SIGNED] ABERDEEN.

We now come to the next period, which marks the greatest advance in the history of the photographic progress, viz: the advent of glass negatives and positives, first applied to lantern slides and stereoscopic views, in the development of which none hold a more honorable position than Francis Schreiber and the two Langenheim brothers. The same may be said of the printing of positives from glass negatives.

In substantiating this claim for Philadelphia, I will quote from the *London Art Journal*, for April, 1851, p. 106, a report which was written by no less an authority than Robert Hunt: "Our attention has been especially excited by some specimens of photographic positives on paper, from glass negatives, which will be exhibited in the Palace of Industry (they are from Philadelphia), to which the inventors have given the names of hyalotypes. In the hyalotype, both the positive and negative impressions are obtained on glass, and the result is as near an approach to perfection as we can imagine. The hyalotype is the invention of Messrs. W. & F. Langenheim, of Philadelphia—these gentlemen state 'We have substituted plate glass for paper in the negative, and also in the positive altering the process to suit the new material.'"

Robert Hunt continues and says:

"The most interesting application of this discovery is the construction of magic lantern slides, taken from nature by the camera-obscura, without the aid of pencil or brush." Hunt then goes on to describe some of the specimen slides, nearly all of which were local Philadelphia subjects, such as "The Spring Garden Hall," "The U. S. Custom House." There was a total of 126 views and portraits in this collection. He further states that the colors of these pictures also

show a peculiarity in the process of the Messrs. Langenheim. We have them of a rich warm brown, a deep sepia and many of them intensely black, showing that the art of toning was known to these Philadelphia artists long before it was practised elsewhere.

At the great London Exhibition of 1851, the Philadelphia heliographers were awarded the medal over all competitors, a fact of which they were advised by an autograph letter of Millard Fillmore, the President of the United States.

These same artists were also the first to attempt the publication of a series of stereoscopic views of American scenery.

In connection with this venture the following card appeared in the *Public Ledger*, during December, 1855:

Langenheim's New Series of American Stereoscopic Views.—We, the undersigned, who by subscribing and furnishing F. Langenheim with the means to commence a new series of American stereoscopic views between Philadelphia and Niagara Falls, have received the number subscribed for, and take pleasure in expressing our entire satisfaction with them, and would recommend them to all who have a desire to cultivate a taste for their own American works of art and skill. They are also colored with much taste and truthfulness to nature.

John Tucker,	Thomas C. Kirkbride, M.D.
R. D. Cullen,	Samuel Sloan,
H. J. Williams,	J. C. Cresson,
Charles Vezin,	Lyon J. Levy,
James Farnum,	Joshua Baily,
James R. Graves,	Samuel Mason,
M. J. Lewis,	Jeremiah Hacker,
C. Gulluc,	Thomas C. James,
J. H. Towne,	James L. Clayborne,
Fairman Rogers,	Charles C. Grugan,

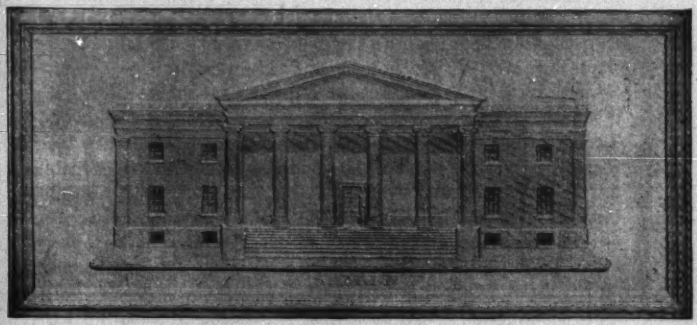
M. L. Dawson.

"*A Card.*—The new series of American stereoscopic views alluded to in the above testimonial were taken in company with the subscriber upon a recent trip to Niagara Falls along the south route of the Reading, Catawissa, Williamsport and Elmira Railroad to the Falls, with the addition of about twelve very interesting views of scenery in the coal regions near Pottsville on the Mine Hill Railroad.

"These pictures are soon to be published upon glass and porcelain by an entirely new process. They are also to be published in a cheaper form upon albuminized paper, and may be had at the publication office of William Lloyd, 188 Chestnut Street, Philadelphia.

"The paper views will be sold in book form, and ready for sale on Friday at Cowperthwaite & Co., under the Masonic Hall, and Parry & McMullan, Fourth and Chestnut. (December, 1855.)"

A complete set of these early views of Philadelphia, either in hyalotype, lantern slides, or stereoscopic prints would be of great interest at the present day. An earnest



The first photo-mechanical reproduction. Made by Joseph Saxton, 1841.

search by the speaker, however, has failed to bring to light any but a few scattering specimens of Langenheim's scenic efforts.

I think that sufficient has been shown in the preceding remarks to prove that Philadelphia scientists from the very start have played an important part in the development of the photographic art-science, and that our fair city may well be called the birthplace of photographic portraiture as well as the mother city of modern photography.

In the development of the dry-plate industry Philadelphia also stands in the advance, the first commercial dry-plates in America having been made in this city. The

reputation of Philadelphia dry-plates and films are known throughout the photographic world.

In scientific research, it is but necessary to mention the names of M. Carey Lea and Frederick E. Ives, both I think members of this Institute; the latter being the inventor of the well-known half-tone process which bears his name, and more lately of a method for the projection of views in the colors of nature by strictly photographic means.

That in our generation the artists and professionals of our city have not deteriorated, is shown by the splendid achievements of Gutekunst and others of lesser renown, all proving themselves photographic artists second to none in the country.

In connection with my subject, I will also call attention that the first negative of a flash of lightning ever taken was made by Mr. W. N. Jennings, a member of this society, September, 1882, proving the fact that the electrical discharges from the clouds were wavy and not zigzag. This peculiar branch of scientific photography since its feasibility was shown by Mr. Jennings has developed into a wide-spread study. One of the most interesting results obtained by Mr. Jennings is the proof that lightning is oscillatory in character, by a series of fine photographs taken from a moving train, while crossing the prairie of North Dakota last summer.

In conclusion, I will call your attention to a few of the earliest heliographic experiments, contrasting them with the latest advances of the present period; these specimens will show the great strides which have been made during the past half a century.

LIST OF SPECIMENS REFERRED TO IN THE LECTURE AND EXHIBITED.

(1) Fac-simile of Saxton's first effort at the Mint of the United States, October, 1839. Original deposited with the Historical Society of Pennsylvania.

(2) Contrast. An Ives heliochromoscope, showing the latest and highest development of the photographic art in the reproduction of the colors of nature.

(3) Fac-simile of the first portrait of the human face by any heliographic process, made by Robert Cornelius, November, 1839.

(4) Comparison: a portrait of the present day, made by Fred'k Gutekunst.

(5) Fac-simile of the first studio portrait, by Robert Cornelius, February, 1840.

(6) Fac-simile of the first instantaneous local views ever placed on exhibition or for competition, by Joseph E. Parker, March, 1840.

(7) Specimen of the earliest daguerreotype by the use of bromine, by Dr. Paul Beck Goddard, December, 1839.

(8) Fac-simile of the first photo-mechanical reproduction, made by Joseph Saxton in 1841.

(9) Specimen of the latest development of the photo-mechanical processes.

(10) Specimen daguerreotype for which Philadelphia became renowned, by Marcus A. Root.

(11) Specimen of earliest paper negative made by Francis Schreiber, Philadelphia, 1847.

(12) Contrast: a negative on flexible celluloid film.

(13) Specimen of photography or talbotype made from a paper negative about 1847. This is one of the earliest efforts at positive photography.

(14) Photograph, view of Fairmount Water Works. One of the earliest positives made from a glass negative. Made for exhibition at the World's Fair, London, 1851.

(15) Portrait of Joseph Saxton.

(16) Portrait of Frederick Langenheim, a talbotype from paper negative.

(17) Portrait of Francis Schreiber, the veteran photographer and co-worker with the Langenheim Brothers, at the age of ninety-one years.

(18) The complete studio outfit of Dr. Paul Beck Goddard, as used by him in 1840.

CAUSES OF FIRES.

By C. John Hexamer.

INTRODUCTION.

In a lecture delivered before the Institute, in 1884, I called attention to the "annual fire waste" in our country, as follows:

"When we consider that in the year 1883 about $100,000,000 worth of property was destroyed by fire throughout the United States, and if losses continue at the present rate they will this year [1884] amount to $128,000,000, we must admit that the study of fires and their causes is of intense interest and of the greatest practical value. For the sums just quoted are so great that the mind cannot conceive them; it is only by comparison that we can arrive at an approximate idea. Let us suppose that a clerk was counting off single dollar notes for the payment of these losses, and that he could count at the rapid rate of 100 in a minute; it would take him 2·43 years to complete his task, without a moment of sleep or rest. Or suppose I placed $1 notes representing the amount of this annual fire waste in line lengthwise, edge to edge; it would form a line of greenbacks 7,893,333·3 feet long; or, to express it in miles, a strip 1,494·9 miles in length.

"All of the former huge amount of property has literally been blotted out of existence. Whether the losses were borne by the insurance companies or by individuals, the result is the complete extermination of just so much wealth which was created by human effort and ingenuity. The world is poorer by that amount than it would have been could these fires have been avoided.

"A person who considers these facts and figures thoughtfully must be impressed with the conviction that the existing means of preventing and extinguishing fires are either very inadequate or very greatly neglected.

"The whole matter will have to receive more consideration in the future than has hitherto been given to it. Civil-

ized society, which leans so much upon human industry, cannot afford to permit vast quantities of the fruits of industry to be blotted out every year, when preventives are within reach."

Matters since that time have not improved, and taking up any insurance periodical, or report, the same lamentations are found in their perusal.

I have before me an address by President George E. Wagner, of the Philadelphia Fire Underwriters' Association, made November 18, 1892, where, in his usual lucid, incisive manner, he speaks of the fire losses in the United States, saying:

"With the increasing wealth of the country, the amount insured increases correspondingly. It has already reached the enormous aggregate of nearly sixteen thousand millions under outstanding policies. Of course, there must be an increase in the number of burnings and the amount of fire losses. It is true they are enormous, the annual ash heap costing the nation about $100,000,000. About $70,000,000 of this amount was last year paid through the insurance companies; that, however, does not alter the fact that the expense to the nation is the whole amount of the loss sustained by reason of the fires, for the companies collected the amount they paid from the holders of their policies in the shape of premiums.

"How to decrease this stupendous destruction is a problem well worth the thought and effort of the statesman, the economist and the business man. Think of it, $100,000,000 per annum of value annihilated! Some through ignorance, some through carelessness, some through criminality, and but little comparatively through natural or non-preventable causes. All statistics of 'fire origin' clearly illustrate my meaning, for 'causes' stated therein, show that the great majority of fires are *preventable*, but we repeat that this destruction is a direct loss of the wealth of the nation, every dollar paid by the insurance companies comes out of the policy-holders, and not out of the coffers of the companies or the pockets of the stock-holders. The owners of the companies pay in a certain capital as a guarantee for the

fulfilment of their contracts, for which the capital is liable. If the receipts of the companies are insufficient to pay the losses and expenses, the capital is impaired, and the law compels the companies to retire from business. Hundreds of companies have been compelled to do this in the past few years, and more must, unless present methods are changed."

I do not wish to mince matters, and therefore state at the outset that the object of this series of articles is to reduce the number of "*preventable*" fires. I will attempt to give the causes of fires in our habitations, and *pari passu*, in our commercial and manufacturing enterprises. In other words to write a short fire technology. Of course, I will be forced to repeat much that I have written in insurance and other technical journals, but which is brought forth here for the first time in what I shall attempt to make a succinct and continued account of my own and the combined experiences of underwriters and inspectors, as far as I have been able to collect them in practice, and from a close study of the literature of the subject and personal interviews.

I may perhaps be able to still more forcibly impress the general importance of the subject about to be treated by giving a few extracts from remarks I made on the occasion of the twenty-first anniversary of the insurance journal, *The Spectator*, in 1889 (printed in full in the anniversary number):

"The more we study the causes of fires, the more surely may we hope to reduce their number. For several years I have attempted to show to the readers of *The Spectator* how easy it is to prevent spontaneous combustion, explosions and fires from many other causes, by exercising a small amount of care. If we know how fires are produced in a certain process of manufacture the problem is solved. All that is necessary is that the insurer and the assured, through constant vigilance, see that at no time conditions may arise which, by the unalterable laws of nature, will ultimately cause a fire. * * *

"It is exceedingly difficult to get people to change their accustomed usages, but it can be done through the

services of efficient inspectors, and the reiteration of principles during frequent reinspections made by competent officials. But do we know all the underlying principles, the laws of nature, that cause fires? To this question we can only answer with an emphatic no; and those who know most of the causes of fires, know best, to use an Hibernianism, how little they actually do know. In order to discover a law of nature, or prove an hypothesis we must be able, by combining the conditions which we think produce fire, experimentally, to actually produce the results we anticipated; if not, our hypothesis was wrong, and we must seek a different solution. What is most wanting in our profession are men who will devote their life to the discovery, and the experimental proofs of the causes of fires. There are enough intelligent men who can be taught the principles, when once established, and who could be told to look for this or that when inspecting a risk [the thing insured] of a certain class, and who would perform their duty faithfully. But not all the principles have been studied, and new and dangerous processes are daily introduced which should be intelligently investigated. These investigations must, however, in our country be carried on entirely through private means, and for the sake of the love the investigator bears to his subject. As the pay of experts and inspectors is comparatively small, it is beyond him, unless he has independent means, to erect a laboratory where such tests could be made, and to carry on experiments which might prove of great value." * * *

[A testing laboratory of this nature, open to competent persons, under proper restrictions, in the proposed "*new*" Franklin Institute building, for which we are still *waiting*, I hope not in vain, for "hope deferred maketh the heart sick," would no doubt result in much good work.]

"Much credit is due the New England mutuals for the excellent labor they have done in this respect; and the money they have thus expended on this specialty has yielded manifold returns. There has of late been a decided improvement in this respect by the stock companies who, through their boards and associations, have been able to do

much. The public, instead of battling and crying out against such combinations, should most earnestly support them, as it is through their efforts alone that the intelligent and careful assured will in the course of time (through schedule rating) be emancipated from the tax of indirectly paying for the losses of the idiotic and careless. That which we frequently call an accident, I must repeat, is very often caused by the imperfect knowledge of materials and natural laws. * * *

"The prospects for the future are not bright, If we wander about an 'improving' city, we must soon reach the conclusion that the fire hazards of large cities are increasing. Without speaking of manufactories, let us for a moment consider that most prized store or mercantile insurance. The first floors of stores, as now built, consist of almost one large window on at least one side; or, if situated at a corner, two sides of the first floor consists of windows. The ultra is reached (several cases in Philadelphia) where the buildings are located at the triangular insersections of three streets, and the entire first floor consists of windows, the building resting on iron piers. If an old corner house is to be transformed into a store, the outside walls on the first floor are torn out, iron piers are inserted, and the wall above rested on iron girders. The modern lavish use of glass and iron has and will still further increase the terrible fire waste to which our country is annually subjected. We can in almost every large city in the Union find great buildings in which we vainly search for one good piece of wall in their entire front, being constructed of iron columns, posts, girders and sheet iron. How are these to withstand the heat of a fire? And how are we to calculate what is a fair distance for exposure, when in a city with a good paid fire department (by means of this glass and iron construction) fires have been transmitted over streets sixty-feet in width. But, more curiously, what shall we say of the building department which allows the building to be rebuilt much higher on iron stilts (filled out with glass) on the first floor? And, most curiously, what shall we think of the companies who had paid for the old building, who again insure this

new and worse building, putting at nought the old adage 'that a burnt child dreads the fire?' Consider, if you can, the disproportion between the construction of such a building and the amount of inflammable material stored in it. Then the amount of care usually exercised in regard to the paraphernalia of lighting, heating, accumulation of rubbish, etc.; then consider that entire rows of such risks exist, and we must admit the outlook for the fire underwriter is not bright. What we need in most cities are better building laws, formulated or revised by committees of intelligent underwriters. We cannot expect merchants to spend large additional sums of money for safer buildings when they are not forced to do it either by insurance companies or municipal regulations. * * *

"If we look into one of these tinder-boxes filled with inflammable stuffs, we are often shocked at the manner in which fires, gas, etc., are used, the lighting of gas and the paraphernalia of heating being intrusted to boys. * * *

"I shall at some future time speak of the accumulation of hazardous materials in large cities, the way in which they are stored and handled, and how they should be stored. In considering in detail all this, and the numerous violations of what even good common-sense would dictate, and further consider that our means of extinguishing fires do not increase in the same ratio with the increase of fire hazards, we must confess that it is wonderful we have not more fire losses. But, fortunate as we are, how long can we afford to let things get worse? How soon will the day come when the business will be so unprofitable that capital will not invest in it? * * *

"The only remedies are:

(1) "Ascertain fire hazards. A national bureau, for tests, experiments, analysis of oils, special investigations, etc., would be but a very slight tax on the nation or even the united companies, and would bring the greatest returns, if the ascertained results are properly applied.

(2) "Better building laws.

(3) "Inspection and reinspection by faithful, competent, well-paid men. No ground floor inspections. A surveyor

who does not know in what condition the attic and the cellar of the house he inspects are, does not do his duty. Insert in survey blanks the questions: 'Is the scuttle supplied with a permanent ladder?' 'Number of lights in cellar, and how arranged?' and see to it that these questions are carefully and truthfully answered. Do not leave your inspections to unreliable persons because they are cheap. What proper inspection will do has again and again been practically demonstrated.

(4) "The co-operation of the press in instructing the public in these vitally important matters, in which it is even more ignorant than matters pertaining to hygiene.

(5) "Mechanics' erecting and heating and lighting paraphernalia should be as strictly watched, and the work inspected as rigorously, by a special municipal department, as the boards of health should look after sanitary matters.

(6) "The office of 'fire coroner,' filled by an especially well-trained expert, should be created in every city, whose sole duty it would be to investigate all fires, and make full reports on causes, etc. The position of fire marshal does not fill the bill."

When an epidemic threatens us, we are apt to inspect and improve our sanitary arrangements and look about for preventives, let us then also investigate the general causes of fire which continually threatens us. Annually, many persons are burnt to death through causes which could have been prevented, a state of things which is an insult to civilized society. Is it not remarkable that an age, wonderful for so many material achievements, has produced so little to prevent fires and save life in case of fire?

Of fires, as is the case in other investigations, it is most difficult to discover the origin. Before preventive measures against enemies of mankind can, however, intelligently be undertaken, be they epidemics or dangers of the elements, we must first know the causes which underlie the evil we wish to overcome. The investigator on this subject labors under difficulties which the student of no other subject encounters to a like degree. The student of a new disease may note the symptoms of a great number of cases, which he

can diligently himself examine; we, on the other hand, receive our accounts from persons who observed what we most desire to know while excited and frightened, and often cases occur where all traces of the origin have been destroyed; while it is exceedingly difficult to obtain information from employés, which would reflect on their judgment, or criminate them.

In order to lessen the number of serious fires, not so much better means for extinguishing, but methods of preventing them are required; and fires can only be prevented by a proper understanding of fire hazards by all classes.

First, however, we must know a few general facts. And, as it is the intention that what is here said should appeal to laymen generally, these explanations are "popular," and will, perhaps, appear puerile to chemists.

What is Fire?—Before we go into details of how to prevent fires, let us first ask ourselves, What is fire? Webster defines it as "an evolution of light and heat in the combustion of bodies, or that active, natural process, by which burning bodies are decomposed with the evolution of light and heat;" this to laymen is rather a vague definition, and conveys to the mind no clear idea.

If we rapidly draw our hand through the surrounding space, we feel a certain amount of resistance. This resistance is due to a gaseous body which surrounds us on all sides, and which we term air, a substance known to the ancients, who tried to weigh it. As, for example, Aristotle filled a bladder and weighed it, then exhausted the air and reweighed the bladder, and actually believed he had thereby determined the weight of the atmosphere. It was not, however, until the advent of the experimental era under Galileo and Torricelli that its weight or pressure was determined. It was found at the level of the sea to be about fifteen pounds to the square inch.

This surrounding fluid consists of two gases, oxygen and nitrogen; not, however, chemically combined, but merely mixed in the proportion—in round numbers—of seventy-nine parts of nitrogen and twenty-one of oxygen. Nitrogen, which is fourteen times more dense than hydrogen, is

a gas entirely negative in its qualities; does not support combustion, and its purpose in the air is merely to act as a diluting agent so as to make the effects of oxygen less violent. Oxygen, the great supporter of life and also the great destroyer in nature, is an odorless, colorless gas, sixteen times (density 15·95) as heavy as hydrogen. It and its combinations constitute the greater part of our earth. The crystalline rocks, which consist of silicates, contain from 48 to 44 per cent., by weight, of oxygen. Water, which is composed of oxygen and hydrogen, contains 88·89 parts, by weight, of oxygen. It is this element which causes almost all those phenomena which we ordinarily term combustion. Phenomena which it causes while ordinarily diluted with nitrogen (air) are greatly intensified when the element is pure; and even metals, such as iron and steel, when ignited in a globe filled with oxygen, burn with brillant scintillations.

We are now ready for the question, "What is combustion?" It might be defined as a chemical union of oxygen with some other element or elements, accompanied by an evolution of light and heat, while similar unions of other substances, not with oxygen directly, might be termed "chemical combination." Substances which unite with oxygen are termed combustible substances, while oxygen is a supporter of combustion. These terms, although but relatively correct—as combustion might be defined as an act of any chemical union accompanied by an evolution of light and heat—are for our purposes very convenient and will be retained throughout.

It has been found that before a substance can ignite (take fire) in either the air or oxygen, a certain temperature must be reached, and this necessary temperature is termed the ignition point or temperature of ignition. While for some substances this point is very low, for others it is extremely high, as, for example, nitrogen will only unite with oxygen at the intense heat of the electric spark; while phosphorus burns slowly at 10° C. (50° F.), as may be noticed in the dark (phosphorescence); it does not burn brightly until heated to 60° C. (140° F.), and zinc ethyl and

phosphuretted hydrogen ignite in the air at the ordinary temperature.

But most bodies do not unite with the oxygen of the air rapidly enough at ordinary temperatures to produce light and heat, but must be heated for a production of active combustion. In the case of the decay of organic matter or the rusting of metals oxidation goes on slowly, producing heat, and the total amount of heat that a decaying log produces in the long time required for its destruction is exactly equal to the amount of heat produced by its rapid oxidation (burning) in a stove. We, therefore, distinguish between quick and slow combustion.

The temperatures of different flames vary greatly. Bunsen found that the temperature of the flame of hydrogen burning in air is 2,024° C., temperature of a hydrogen flame burning in oxygen 2,844° C., carbonic oxide 1,997° when burning in air, and 3,003° C. when burning in oxygen.

In order to measure the quantity or strength of a material or force, we must have a measure or standard of comparison. The standard for the measurement of heat, if the expression be allowed, as heat is a force and not a material, is the "thermal unit," the amount of heat required to raise the temperature of one gram of water 1° C. This measure is now almost universally employed by scientists, although the old English caloric unit, the amount of heat required to raise one pound of water 1° F., is yet sometimes employed. Two other units are also used: in Germany, the amount of heat required to raise one kilogram of water 1° C. is much used; while the unit of one pound of water to 1° C. is sometimes employed.

Numerous experiments, made by different scientists, have proved beyond a doubt that a constant quantity of heat is given off when the same weight of the same substance burns to form the same products of combustion, whether the combustion proceeds slowly or rapidly. Numerous measurements of the amount of heat disengaged by the combination of different substances with oxygen have been made, of which those of Andrews, Julius Thomsen, Favre and Silbermann are the most nearly correct. The following

tables, compiled by Roscoe, show the heat of combustion in thermal units for one gram of substance burnt:

COMBUSTION IN OXYGEN.

One Gram of	*Thermal Units.*	*Observer.*
Charcoal,	7,273	Lavoisier.
	7,167	Dulong.
	7,912	Depretz.
	7,714	Grassi.
	8,080	Favre and Silbermann.
	7,900	Andrews.
Diamond,	7,770	Favre and Silbermann.
Natural graphite,	7,811	Favre and Silbermann.
Gas carbon,	8,047	Favre aud Silbermann.
Hydrogen,	34,462	Favre and Silbermann.
	33,808	Andrews.
	34,180	Thomsen.
Sulphur,	2,220	Favre and Silbermann.
	2,307	Andrews.
Phosphorus,	5,747	Andrews.
Zinc,	1,301	Andrews.
Iron	1,576	Andrews.
Tin,	1,233	Andrews.
Copper,	602	Andrews.
Marsh gas,	13,063	Favre and Silbermann.
	13,108	Andrews.
	13,120	Thomsen.
Olefiant gas,	11,858	Favre and Silbermann.
	11,942	Andrews.
	11,957	Thomsen.
Carbon monoxide,	2,431	Andrews.
	2,403	Favre and Silbermann.
	2,385	Thomsen.

The importance of all this will become apparent when we begin the study of what are commonly known as "spontaneous combustions," but to conclude the facts with a brief statement:

Whenever a body combines with oxygen, chemical action takes place, and the transformed energy is shown in the form of heat; and if more violent, in the form of light; that is, combustion, or differently stated, *fire!*

After this rather lengthy preamble, I will ask you to take a journey through our homes, places of manufacture and

amusement, warehouses and stores, studying in each the things we meet as we pass through, in relation to their likelihood of producing fire; and first of all, as "charity begins at home," we will study the causes of *fires in dwellings.*

[*To be continued.*]

RESISTANCE TO SHIP'S MOTION: A NATURAL LAW NEWLY DISCOVERED.

By F. M. F. Cazin.

[*Continued from p. 216.*]

Before entering on the task of rendering such proof, on which alone the acceptance of my equation can be demanded, I should state, that there was a time, when I inclined to the belief, that the facts underlying my equation were almost self-evident to such a degree, that they needed only to be stated, in order to be accepted even by the most critically inclined intellects. And only by actual test did I find out what inherent power belongs even with scientists to habitual course of thought or conception. And almost as an excuse for the thoroughness adopted here below in rendering proof, I shall quote some criticism, that my equation was met with, by even such men as are teaching mechanics in one or another of their branches of practical application at technical colleges on this continent.

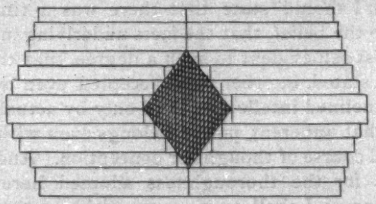
The one, when the question of displacement in inverse direction to movement of solid of the precisely stated quantity of the medium was submitted to him, at once undertook to declare the claim to be a fallacy, and to support his declaration, he did not rely on any mechanician of renown, as those hereabove quoted, but he substituted for their and my valuation a brand-new one of his own, that is for the movement of medium in inverse direction of the solid's progress an exclusively lateral movement of medium.

And in this opposing view the other learned professor at once concurred, and jointly they expressed themselves thus:

"Mr. Cazin has apparently overlooked the possibility of lateral displacement. That the displacement is lateral and not in a direction contrary to the movement of the solid, should be *self-evident*, but may be made clear by a simple illustration. Let us imagine a mass, in the form of a double wedge, forced through a pile of boards, which slide out of the way, as the wedge passes, and return to their original position, after it has gone by. These boards may be taken to represent thin films of water, which in like manner move out of the way laterally, as the solid passes.

"If the water be confined by the walls of a vessel, the various films will be increased in thickness, as the body passes.

"This increase in thickness is less, the larger the vessel, and *nil* in *unconfined* bodies of liquid. This thickening



of the films represents a certain elevation of the water and a certain amount of work. This work is, however, returned, after the body passes, and the film resumes its original thickness.

"The lateral displacement of the water, apart from questions of friction, impact, inertia, etc., does not absorb any power, when the body in question moves in large bodies of liquid, permitting lateral and not vertical displacement.

"Mr. Cazin's error seems to us to be fundamental, and to vitiate his conclusions and results derived therefrom."

How modestly did Weisbach express in comparison with the claim of these learned savants, that their new opinion is "self-evident:" "We cannot specify the value of these resistances *a priori*," says he, "but we may assume, on account of the great similarity of conditions, that at

least the general law for percussion by unlimited quantity of water does not vary from the law for the percussion resulting from isolated jets."

And, indeed, all that Weisbach claimed was and ever remained true, only that he did not fully solve the problem, as I claim, that based on this master mind's teaching, I now have solved it. But my adversaries of to-day pass over all learned predecessors, as if they never had existed. They build not on what these master minds prepared, as I clearly did, but they ignore them entirely.

To the trained mechanician I need not point out, that, if what my adversaries claim were true, it would solve the perpetuum-mobile conundrum.

At no time has there been offered a truer representation of the water jet flowing with the pressure or head (constant) proportionate to a given velocity, than is by me offered in my new equation, where the value for pressure or head (S) is borrowed from the old masters, and is made to answer the requirement of a true representation by making the other factor the precise quantity and weight of water, (relating to the same time unit [second] as the value v) that is active in causing the stated effect.

I must now ask my readers to favor me with their good-will in making up by keen perception what my demonstration may be deficient in cleverness and transparency of expression.

IMMERSON OF SHIPS.

We all know that, when a ship is launched, and when subsequently she has come to rest, there is, so to speak, as the result of the proceeding, a cavity in the water, where there was previously none, and in the cavity so produced in the water the ship is resting. If the ship had been let go into a tank, and the walls of that tank had previously been marked for volume (for cubic metres) of contents, the launching of the ship would have caused the surface of the water to appear after the launching higher up than it was before. And the *increase in elevation of the surface multiplied by the area of surface would show the precise volume* of the immersed part of the ship. And the weight of the volume

of water so measured would be precisely equal to the weight of the total ship, the ship weighing one metric ton for every cubic metre or one kilogram for every litre of water displaced by the ship in her immersion.

The value of "buoyancy" (= B) therefore represents the volume of the immersed part of the ship or her total displacement, *when at rest*, and, when such incipient displacement is expressed in metres, also the total weight of the ship in metric tons corresponding to cubic metres, or in kilograms corresponding to litres.

The word "tonnage" cannot well be substituted for the word "buoyancy," because by tonnage old usage understands loading capacity. It is this volume of water (= B,) which my readers will then know under the name "buoyancy," that I shall have eminently to deal with, and it becomes a necessity in dealing with this value as a volume, to find for it a form or shape equally *representative of all ships* as the value *buoyancy* itself is. The standard form to be selected should not only preserve all the essential or important characteristics of the forms of all ships coming under consideration, but should also in the same expression represent the different positions relative to the water and to the direction of her motion, that the ship may assume during such motion.

In the course of my research I found two dimensions for the volume "buoyancy" which, although new to mechanics and nautics, properly and appropriately described the volume and weight of medium displaced by first immersion, which latter value for valid reasons it will be proper to henceforth always designate as the *buoyancy* of the immersed or submerged solid.

These two dimensions or factors correctly describe the precise value of such *buoyancy* (B), and *buoyancy* divided by either must measure the other of the two dimensions, and both must describe *buoyancy* as a volume and form of uniform transverse section in its entire other dimension, in order to properly represent a uniform and continuous effect.

For ships in normal movement, their length measured on

the water line would constitute the one of these factors $= d$.*

$$\frac{B}{d}$$

then must produce the other value ($= f$), representing a transverse uniform section of the ideal form for the value *buoyancy*, and this factor f may then properly and appropriately be called "transverse average section" ($= f$). And

$$B = d\,f \text{ and } \frac{B}{d} = f$$

In the old valuation of resistance to motion in submersion, the values a and b (face angles) were made dependent on length between these solid angles and the central transverse major section (Ms), and represented stable values leaving no possible mutability or adaptation of values to the different position, that the ship's body might assume relative to its movement. But the correct valuation of d (measured in the direction of motion) accounts for such mutation.

The value

$$f = \frac{B}{d}$$

then represents truly and correctly the comparative, continuous, uniform or permanent resistance to ship's motion, because such resistance at any stated moment is the same as in all other moments under the same conditions, and

* While experimenting, it became soon evident to me, that the constructive length of the solid (for ships on water line), although analogous to the natural direction of its movement, would not be a proper dimension in describing an ideal form, by which the resistance to the motion of all or any solids as affected by the medium might be measured, but I found the value ($= d$) for the shortest line (for ships drawn in the plane of the water's surface) drawn in the direction of the relative motion, or a parallel with such direction, between perpendiculars on direction of motion, passing through the temporary extreme ends of the ship, to be adequate in describing the ideal form of solid Whether then the solid move in the direction of its greatest length or not, the values d and

$$\frac{B}{d}$$

would properly express the relation between volume and movement.

for equal lengths of time it is equal and constitutes a factor to the value, that relates to the stated time. And when a flow of water were under consideration, then this value *f* would be the area of action, the transverse section (current of the electrician*), and with the distance of flow per second as the other factor, the product would precisely give the quantity of water passing any stable point within such second. And this product would also state the precise mass of water, that with the proper factor for movement (impulse) in such mass would correctly specify the total kinetic effect of such moving mass per second.

None of these qualities or virtues possessed by the value *f*, that is, by "transverse average section," is attributive also to the value *Ms*, that is, to "transverse major section."

Were it not for this by me newly introduced value of "transverse average section," that is, of the volume divided by length, the accurate valuation of resistance to motion of solid in a medium would have remained impossible.

WHAT HAPPENS TO THE MEDIUM WHEN A SOLID MOVES IN IT?

If a steamer obtains her buoyancy by displacing 12,000 metric tons or cubic metres of water, and has a length of 200 metres, then her "transverse average section" (*f*) is as $B \div d = 12{,}000 \div 200$, or as sixty square metres.

I assume that this is the steamer just before-mentioned, of which I described the launching in the preceding lines, and that she is housed at the Cunard pier in North River, New York, ready to start on her voyage to Liverpool.

Where this steamer lies at her pier, there is, so to speak, a cavity in the water, which is filled with the lower part of the steamer's body. As we know the steamer's buoyancy (= 12,000 tons), we also know the precise weight of the water, which would fill that cavity, and which had to go *to the surface* of the bulk of the water, when the ship was launched and later on more thereof, when she received both her permanent and transient load.

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* Compare the author's series on "Electro-metallurgy." *The Electric World*, vol. xx, No. 10, September 3, 1892.

If we may imagine all the water around the steamer frozen solid (assumed without change of volume), and the steamer lifted out of the cavity in which she rested, then there would be precisely such a cavity in the ice, which to fill it would take the precise 12,000 metric tons of water, measuring precisely 12,000 cubic metres in volume (as water), which made the steamer's buoyancy.

For the sake of illustrating some other very important facts in the premises, let us suppose that the Cunards must move that steamer, in the ice, for a distance equal to her own length.

They would first be obliged to have a cavity cut at the new and adjoining place, and such cavity would be required of precisely the same dimensions as the one before described. And then they might get the ship thereinto as best they could. And when the job had been done, what would be the proper description of the work actually performed?

The medium being considered as only temporarily solid, in order to better illustrate changes in the position of parts thereof, I shall use this assumption exclusively for showing and demonstrating these changes in the position of parts of the medium, without as yet discussing the road, by which such parts of the medium perfect these changes in their position.

We should, after the removing of the steamer out of the cavity, in which she rested originally, into an adjoining equal cavity, situate on the line of her normal motion, have the following changes:

(*a*) The steamer in her new position, would have travelled over the distance *d*.

(*b*) A quantity *B* of (frozen) water had been taken out of the cavity, where the steamer now lies.

(*c*) There would be a cavity in the (frozen) water, where the steamer lay, before it made the specific movement, such cavity being in volume equal to *B*, and the water, which would fill this cavity would also be equal to *B*, or equal to the quantity removed out of the second cavity.

If then we assume this later quantity, which was

removed out of the second cavity to be stored in the yet open first cavity, it will no longer be necessary to continue the spell of solidification for the medium water, because as a liquid even the changes as hereabove specified will remain undisturbed, until the ship move again.

The result then observed may properly and correctly be expressed as follows:

(1) In moving the distance *d* a ship causes a volume and weight *B* of the medium to be moved inversely to her own movement.

My illustration shows the result of three such removals.

Had the ship, when frostbound, been actually and bodily lifted out of the cavity, in which she originally lay, and had

Vertical section of successive cavities.

Horizontal section of successive cavities.

Groove caused by continuous motion.

she been removed to another more distant place, the ultimate results, as they were expressed under *a*, *b* and *c* would have remained in all but the distance of removal absolutely the same, and it may therefore be correctly stated, that

(2) The movement of a ship causes a movement of her own weight of the water (medium) in inverse direction, for the distance of her own travel.

Before finally dismissing the spell of solidification from our medium, water, we shall yet consider the effects of a sliding motion when brought about in the ice the same, as it occurs in the liquid water.

The effect of such sliding motion, which is the veritable motion of the ship in the water, will be more clearly shown,

when both the real form of ship with non-uniform transverse section and the ideal representative of the same (immersed) volume, having a uniform transverse section, will be considered.

This ideal representative of the volume B of 12,000 cubic metres and of a length $= d = 200$ metres must have a section f of sixty square metres. And in order to otherwise foster greater similarity, the section f may be assumed as an equilateral triangle, and if the density of the volume be assumed as $= 1$ for the total, with a larger portion of mass in one of the long solid angles, then this ideal body B will take a position in the water corresponding precisely to that of the ship.

Such a ship B of ideal form would originally lie in a groove-shaped cavity, and when an adjoining equal cavity be cut in the direction of normal motion, this ship may be caused to slide along for the distance d without any but the quantity B of the ice being removed, the total effects being exclusively those hereabove described under a, b and c.

But if the ship B had the usual shape combined with the same volume B and the same length d, non-uniform transverse sections, it would require a groove of such increased transverse section as the ship's transverse major section ($= Ms$) would call for, in order to let the ship slide in its groove. This would result in the necessity to remove temporarily in addition to the quantity B of the ice an additional quantity thereof being as d $(Ms - As)$, Ms standing for "transverse major section," and As standing for "transverse average section," the latter being

$$As = \frac{B}{d}$$

And the necessity of removal of this so defined quantity of the medium would be the result of form (shape) of solid exclusively, and it also would be of an entirely different character altogether, because it would not constitute a removal of a permanent character, but such removal would be temporary only, the portion of the um thus removed

finding room, after the ship's progress at or in the precise location, where it was before, while the quantity B must actually be moved in inverse direction to the ship's movement and for the distance of the ship's travel, in order to find room below the level of the water's surface.

It has therefore been shown, that a real and permanent change of position of the quantity B only of the medium is caused by a solid's motion in sub- or im-mersion.

The quantity $d\ (Ms - As)$ of the medium falling back into its original position reproduces the force spent on its temporary removal, because the movement started (inertia, thus measured, overcome), this temporary (lateral) displacement and immediately following reoccupation of the original position is also practically continuous, simultaneous the one with the other, and uniform, the same as is the permanent continuous displacement of medium in inverse direction, that results from the movement of the ship.

It therefore follows, that in valuation of the total displacement of medium directly, inevitably and effectively caused by the movement of a solid in submersion, this complement $d \times (Ms - As)$ need find no place, and that the permanent displacement of medium in inverse direction to motion of solid alone produces the resistance to such motion.

Having utilized the assumption of the medium being temporarily frozen solid, in order to unmistakably show, that the movement of the solid in a medium really causes the removal of the quantity B of the medium in inverse direction to the movement of the solid, for each distance $= d$ that, the solid itself travels, we may now abandon this assumption. But the conclusion must be drawn from what has been shown, that a quantity of the medium $= B/d \times D$ ($D =$ distance of travel) is moved in inverse direction of the solid's motion for a distance $= d$.

It then remains to consider the movement of the ship (or of a horizontal column of the same submerged volume, but of uniform transverse average section) with the assumed solidification of the medium removed. This transmutation back from ice to water leaves the stated quantities of the medium whether solid or liquid in their relative positions,

the *road only* by which these quantities changed their positions mutually presumably were different, had we dealt with water and not with ice. Actual displacement in inverse direction to motion by a solid moving in a medium can no longer rationally be denied, and the road only, on which the medium travels backward, for changing position, whether it be a direct one or an indirect one, or one by substitution in part or in total, this road, the road by which the medium travels backward, remains to be determined.

I may then be permitted at the hand of the information thus obtained, to describe the effect of the solid's motion in the "liquid" medium. It is not claimed, that the identical drops or molecules of the water in total fall back into identical relative positions in the cavities to be filled one after another. The water in its total mass is subject to mutation in position of parts all tending to the maintainance of its hydrostatic equilibrium, but so much is claimed only as is essential, namely, that the stated quantity of the medium changes position relative to the moving ship inversely to her motion.

When the ship moves ahead, the stated quantity of water, which is to move from head to stern, is being displaced continually at the precise, same rate in front, that room is made for it astern, and it must and will take the shortest possible road for its change of position, as an absolute consequence of its quality as a liquid for re-establishing thereby the hydrostatic equilibrium, which was disturbed through the ship's motion.

In the case of the ship, as we are accustomed to construct her, the water slides along the curves of her sides, a movement easily ascertainable in practical navigation and having in the case of screw-propellers a name even, as "propeller suction."

We know the precise quantity of water so moved by the ship's motion in inverse direction thereto, but we also know by the instrumentality of the same law, the precise, complementary quantity of water causing a lateral swell and falling back into its previous position.

The question, whether non-uniformity of transverse sec-

tion results also in non-uniformity of back flow of medium and of resistance overcome at different stages of motion might be raised. The conditions to resistance remain constantly the same, therefore resistance itself must be uniform. Therefore the solid's uniform transverse average section,

$$\left(=f=\frac{B}{d}\right)$$

being uniform for all times and distances of motion, can alone truly represent the uniform distribution of resistance over all moments of motion. Is it therefore clearly shown and fully demonstrated, as heretofore stated, that:

(3) A solid moving in submersion a distance ($=d$) equal to its own length, measured in the direction of motion, displaces of the medium in inverse direction, for the distance of its own length a volume of the medium equal to its own immersed or submerged volume, ($=B$) and when moving any other distance moves the volume B of the medium, for the distance of such travel in inversed motion to its own motion.

And on this foundation the entire new system of valuating resistance to submerged motion can be built up by mathematical evolution.

I do, nevertheless, consider it as opportune to yet describe one other easy and very interesting method for proving displacement in inverse direction of measurable quantities of the medium by the movement of a solid in submersion, which can be applied by all, and which leaves no further room for scepticism to the most critical but unprejudiced mind.

[*To be continued.*]

PROCEEDINGS

OF THE

CHEMICAL SECTION

OF THE

FRANKLIN INSTITUTE.

[*Stated meeting, held Tuesday, March 21, 1893.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 21, 1893.

Dr. Wm. H. Greene, President, in the chair.

The special committee appointed to prepare a memoir of the late Dr. F. A. Genth presented, through Dr. Keller, an elaborate paper, embodying an account of the life and scientific work of the deceased, including a complete list of all the papers published by him. The paper was referred for publication in the *Journal of the Institute*, and on motion the committee was discharged, with the thanks of the Section for the thorough manner in which it had discharged its duties.

A letter of resignation from Mr. A. T. Eastwick was read, and on motion the resignation was accepted.

A bill amounting to $38.38 from the Institute for expenses of postage, etc., incurred in connection with sending out notices, and for the work involved in the separate binding of the volumes of Proceedings for 1892, was read, and on motion was referred to the Treasurer for payment.

Dr. Wahl, as conservator of the Section, reported that he had in his possession fifty-two copies of vol. i, ninety-seven copies of vol. ii, eighty-two copies of vol. iii, and forty-five copies of vol. iv of the Proceedings of the Section, and in reply to his inquiry as to what disposal should be made of them, the Section voted to leave them in his hands to dispose of in the interests of the Section in such manner as his judgment might dictate.

Dr. Wahl then read a paper, which was the joint production of himself and Dr. Greene, on a "New Method of Reducing Metallic Oxides."

It was received with much interest by the members present, and after some discussion by Dr. Hall and Dr. Wahl was referred for publication. Specimens of the products of the process were exhibited.

The Section then adjourned.

WM. C. DAY, *Secretary.*

On PHENOLPHTHALEIN and METHYLORANGE as INDICATORS.

By Mary Bidwell Breed.

[*Read at the stated meeting of the Chemical Section, held February 21, 1893.*]

In using phenolphthalein as an indicator in alkalimetry, there are certain precautions necessary that have not been sufficiently insisted upon in the literature of the subject. The following experience, however, will show the necessity for great care in its use.

During the standardization of a hydrochloric acid solution against normal caustic potash, phenolphthalein and methylorange were both used as indicators; and it was observed that, while with methylorange 20 cc. of the acid required only an average of 19·443 cc. of the alkali for neutralization, with phenolphthalein the same amount of acid required an average of 19·765 cc. of alkali, a difference which would introduce a considerable error. The same results were obtained with phenolphthalein, even when the solution was heated to boiling, and so it was believed that carbon dioxide could not be the cause of the discrepancy. That the source of the difficulty lay with the phenolphthalein, and not with the methylorange, seemed probable from the fact that it took more alkali to bring the color of phenolphthalein than to discharge that of methylorange; and also from the fact that, while the amounts of alkali used with the former varied from 19·65 cc. to 19·8 cc., those used with the latter were practically constant, differing only by 0·025 cc. Nothing could be found in the literature of the subject that threw any light on the problem. Fresh solutions, prepared with great care, gave analogous results, and after many fruitless attempts to explain the discrepancy, it was concluded that traces of carbon dioxide, dissolved by the alkali, must after all be the source of error. This would explain matters; for acid potassium carbonate, which would be formed in the solution during titration, is neutral to

phenolphthalein, but alkaline to methylorange; and, therefore, as part of the alkali had been rendered neutral to phenolphthalein, it would take more of the solution to affect that indicator than to affect methylorange. This explanation was proved to be correct by prolonged, hard boiling of the solution, when using phenolphthalein. Alkali was titrated with acid, in this case, and it was found that, by boiling ten minutes or so after the end point had been apparently reached, the color could be made to reappear, and that it continued to reappear after each addition of acid until the amount of acid used was exactly equal to that used with methylorange. As the end point was approached, longer and longer periods of boiling were necessary after each drop added. A single titration never took less than an hour.

In view of this, a word of caution seems necessary. It is never safe to use phenolphthalein unless the solution is known to be absolutely free from carbon dioxide, or unless it is boiled long and thoroughly after the end point is apparently reached. As it is nearly impossible to keep a solution of caustic alkali entirely free from carbon dioxide, a titration with phenolphthalein is often as tedious as a gravimetric determination.

Phenolphthalein is probably used at present more extensively than any other indicator, but these objections make it desirable to adopt something more reliable and convenient. Methylorange is not affected by carbon dioxide, and when a sufficiently dilute solution is used, its end point is sharp. It has been found very satisfactory for sensitiveness and accuracy, and it is therefore strongly recommended wherever it is possible to use it.

CHEMICAL LABORATORY,
BRYN MAWR COLLEGE, PA., January, 1893.

DISCUSSION.

MR. HAINES suggested that the glass beaker may have been attacked by the boiling alkaline solution, resulting in extraction of alkali from the glass, especially if the boiling was continued as long as an hour. Such action has been

observed even with Bohemian glass. The glass is stated to be generally attacked as a whole. As regards phenolphthalein and methylorange he wished to call attention to the statement by R. T. Thomson, in his comprehensive papers on indicators (*Chemical News*, **47**, 123, 184, and **44**, 32, 38, 119), that phenolphthalein has five times greater delicacy or sensitiveness than methylorange. In other words, in 100 cc. of distilled water, the former requires but 0·1 cc. of excess of deci-normal solution, while the latter requires 0·5 cc. of excess to produce the full change of color. In solutions of normal strength the difference is scarcely noticeable. He showed that this difference was not due to carbonic acid, but to the interference of neutral salts of sodium potassium, and ammonium formed during tritration, which affect the delicacy of methylorange, but not phenolphthalein, except in the case of salts of ammonia. Neutral salts of calcium, barium and magnesium have the same effect upon methylorange. Mr. Haines said that in recently making some determinations, requiring the use of both of these indicators, he had found the above statement as to this difference to be correct. A fresh standard solution of sodium hydrate, made from metallic sodium and carefully protected, gave practically the same results as an old solution of ordinary sodium hydrate in white sticks. In determining alumina volumetrically in sodium aluminate by the method described by Lunge (*Jour. Soc. Chem. Industry*, 1891, p. 314), in which both indicators are used and the amount of alumina is calculated from the difference of results of titration, Mr. Haines obtained results which agreed very closely with gravimetric estimations in the same solutions if the above correction for difference in delicacy of indicators was applied. Generally, methylorange is used only in a cold solution, but Lunge has shown that in estimating alumina volumetrically with methylorange, the solution should be heated to 30° to 40° C., but not exceeding the latter temperature. The action in the cold solution is too slow and the alumina is apt to be underestimated. Only dilute solutions of alumina should be used.

Phenacetolin also is a more delicate indicator than

methylorange, being similar in this respect to phenolphthalein. In estimating calcium, magnesium and sodium carbonates, as in Hehner's method of determining hardness of waters, Mr. Haines has found, as others have also, that phenacetolin is preferable to methylorange, but in this case the former must be used hot, the latter cold. He finds that the alcoholic solution of phenacetolin keeps very much better if it is not filtered from the insoluble residue found in the article as sold.

Mr. Haines has also experienced some difficulty in obtaining the true methylorange (helianthin). Sutton incorrectly describes it as of a bright orange-red color; Allen states it is orange-yellow. An article of bright orange-red color sold in this country as methylorange gave the *reverse* of the correct colors with acids and alkalies and was so wanting in delicacy as to be practically worthless.

The article recently obtained from Bullock & Crenshaw, which agrees nearly with Allen's description, he had found to be perfectly satisfactory.

MR. HENRY PEMBERTON, Jr., remarked that in titrating with phenolphthalein and with methylorange as indicators, different results would be obtained if the standard alkali contained alumina. This impurity is not infrequently present in sodium or potassium hydrate. Even a small amount of alumina [*about* 0·002 grams] will require when methylorange is used 1 cc. of $\frac{N}{10}$ acid more than when phenolphthalein is used.

In regard to titrations with phenolphthalein in the presence of ammonium salts, J. H. Long has shown* that correct results are obtained when the solution is kept cold, and a sufficient quantity of the indicator is employed.

PROF. E. S. KEISER, in reply to Mr. Haines, said that while according to R. T. Thomson, methylorange was not as sensitive as phenolphthalein, other observers had found it to be more sensitive. For example, J. Wieland (*Berichte d. Deutschen Chem. Gesell.*, **16**, 1989), found that from three to four times as much of a $\frac{1}{100}$ normal solution was required

* *American Chemical Journal*, **11**, 84.

to bring about the change of color with phenolphthalein as with methylorange. That is the phenolphthalein is less sensitive than the methylorange. Experiments made in the speaker's laboratory indicated that methylorange when used in the proper dilution was fully as sensitive as phenolphthalein. The great objection, however, to the use of phenolphthalein in ordinary titrations is its sensitiveness to carbon dioxide, and that it is neutral to acid carbonates. For example, R. B. Warder (*American Chem. Journal*, **3**, 55) has shown that alkaline solutions of this indicator can be decolorized by shaking them with air, and that by simply breathing upon the red liquid the color is discharged. The phenolphthalein is not colored by acid carbonates. Mr. Haines would find in the paper by R. T. Thomson, to which he refers, that that author distinctly states that when alkaline hydroxides containing alkaline carbonates are titrated and phenolphthalein is used as indicator, the color disappears when the hydroxide is neutralized and the carbonate changed to acid carbonate. That if the solution is then boiled the color reappears because the acid carbonate is decomposed, and more acid must be added and the titration continued until the color no longer appears in the boiling solution.

As it is almost impossible to prevent standard alkali solutions from absorbing carbon dioxide from the air, it is evident that the strength of such solutions will constantly change if the determinations are made with phenolphthalein as the indicator. On the other hand, if the titrations are made with methylorange as the indicator the results are in no way influenced by the amount of carbon dioxide that has been absorbed. Hence, in all ordinary work it is advisable to use methylorange.

PROCEEDINGS

OF THE

ELECTRICAL SECTION

OF THE

FRANKLIN INSTITUTE.

[*Stated meeting, held Tuesday, February 28, 1893.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 28, 1893.

Mr. Elmer G. Willyoung, President, in the chair.

Present, thirteen members and visitors.

The minutes of the previous meeting were read and approved.

The Treasurer reported the cash balance in the treasury, and presented bills for printing, etc., which were approved and ordered paid.

It was moved and carried that in future the annual volumes of the Section's Proceedings be sent to members of the Section, but to non-members only on the joint order of the President and Secretary.

Mr. Robert H. Laird was elected Secretary and Treasurer of the Section, for the unexpired term of Prof. L. F. Rondinella, resigned.

Mr. Geo. F. Stradling was unable to present his paper on "The Migration of the Ions," on account of illness, which prevented his attendance.

Mr. Carl Hering made some interesting remarks on "The Smashing Point of Incandescent Lamps," with blackboard illustrations. Taking the decreasing efficiency of a lamp into account, and the correspondingly increasing total expense per candle-power per hour, he showed from the results of Professor Thomas' tests of American lamps, that it would be most economical to renew the lamps after running them 400 or 500 hours. The subject was discussed by Messrs. Pike, Rondinella, Billberg, Winand and Willyoung and other interesting points in connection with incandescent lighting were brought out.

Mr. Carl Hering presented a list of all the electrical journals published in the English, French and German languages. Referred for publication.

Upon motion, the President appointed a committee, consisting of himself and Messrs. Hering and Pike, to arrange for the entertainment of members at the meetings of the Section.

Adjourned.

L. F. RONDINELLA, *Secretary.*

SOME PRINCIPLES THAT MUST BE OBSERVED IN ORDER TO MAKE A GOOD CLOSED-CIRCUIT BATTERY, AND A NEW PORTABLE DRY CELL DESCRIBED IN WHICH THESE PRINCIPLES ARE APPLIED.

BY E. F. NORTHRUP.

[*A paper read before the Electrical Section, Dec. 28, 1892; Jan. 24, 1893.*]

[*Continued from p. 237.*]

Porous Partitions.—A full discussion of porous partitions and terminals is too special for the limits of this article, for each style of cell requires some particular device. If the terminals are in contact with the electrolyte they must, of course, be of the same potential, not necessarily of the same material, as the electrode to which they are attached. Thus, a platinum wire fastened to carbon will cause no appreciable local action. As stated above, the best results will be obtained when the carbon electrodes are so constructed that they will serve a double function of porous cup and electrode. In all cases a porous cup should be avoided where it is possible, for it is so much dead resistance in the cell.

The Seal.—The seal for a small dry cell is one of its most important parts and one not so very easy to construct well. It is astonishing what deterioration and changes time will work upon a battery. In fact, the time test for a battery, as for most things, is an extremely important one. "Will it last?" is the pertinent question, and the way this must be answered depends not a little upon the security of the seal. A warning, however, is easier to give than a remedy, as the many patents taken out for seals alone will go to prove. The expansions and contractions that take place with changes of temperature are almost certain, sooner or later, to produce an opening through which the contents of the cell will creep and cause its final destruction, unless the seal be well constructed. The neophyte inventor cannot give too much attention to this apparently insignificant feature of a closed battery.

Secondary cells have largely taken the place of primary batteries which are designed to supply much current, but

the demand for small portable cells has been rapidly increasing and nothing is likely to be invented which can replace them. Such cells are required by the physician to run his induction coils, and something of the sort is an absolute necessity for use in Wheatstone bridges and portable testing sets. Considering the very extensive demand for a small, compact and efficient dry battery, it is very surprising that the market is not better supplied. There are only two kinds now offered for sale which have any value whatever. They are both very expensive and must ever remain so, as they employ a silver salt for the depolarizer, and their electro-motive force, furthermore, is very low. Now, for the testing of resistance, especially high resistances, a high electro-motive force is required in order to make close measurements. If the resistance of the total circuit is great as compared with the internal resistance of the battery, the deflections of the galvanometer before a balance is obtained in the bridge are practically proportional to the total electro-motive force of the batteries. Hence the number of batteries required is inversely proportional to their electro-motive force. For testing work then, a cell with a volt and a half is just fifty per cent. better than a one volt cell. Cells employing a silver salt give at the most only 1·13 volts and average but about nine-tenths of a volt. A high electro-motive force is not the only requisite. A cell should even for test work have less than forty ohms internal resistance and for the running of induction coils the lower its internal resistance the better. Long life on open or closed circuit is also a desirable feature, for replacements are both expensive and annoying. But what is far worse than a gradual deterioration, which is seen and can be calculated for, is a sudden going to pieces of the cell, which may leave a man helpless in the midst of pressing work. This is a serious fault of the silver chloride battery, for they often generate a gas which sooner or later causes them very unexpectedly to explode.

I desire to bring to your notice to-night some new dry cells, one type of which is designed for testing use and another for running induction coils. They are the final result arrived at after some months spent in experiments at the electrical laboratory of Queen & Co.

The points brought out in this paper were kept well in mind in the construction of these cells and after many changes in the details the following forms of cells were finally settled upon:

The "Test" Cell.—As portability is a great desideratum with test cells and as only a very small current is taken from them, the cell designed for this purpose was reduced

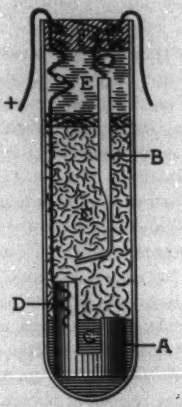

FIG. 1.—Small iodine test cell, 2 inches long by ½ inch in diameter.

A = carbon electrode.
B = zinc electrode.
C = paste made of $AlCl_3 + ZnO + MnO_2 + H_2O$.
D = fine platinum wire moulded into carbon electrode.
E = viscous seal.
F = plaster Paris seal.
G = depolarizer, which may be I_4S_2 giving 1·35 volts, or $HgO + I$ giving 1·65 volts initially with an average of 1·4 volts.

in size very much from those usually used. They are made in what are called round bottom specimen tubes. The smallest size constructed have a length of two inches with an outside diameter of only half an inch (see *Fig. 1*). In spite of this small size the average resistance of these cells when first made up is not greater than twenty-five or thirty ohms, and after the cell has been put in use the resistance grad-

ually falls a few ohms. The electro-motive force of this cell when the depolarizer is sulphur iodide (I_2S_2) is 1·45 volts. They will thus average 1·4 volts. The silver chloride cell with a case of paper and paraffine upon it, which is required to keep the glass from flying when they explode, measures $2\frac{1}{4}$ inches in length by $\frac{1}{8}$ of an inch in diameter; being round they thus have a total volume of 1·62 cubic inches. One of the cells here described, which I may call the iodine cell, iodine being the active depolarizer, has but four cubic inches or less than one-fourth the volume of the silver chloride cell; or 100 silver chloride cells would require seventy-six square inches of space against twenty-five required by an iodine cell. Further, as the electro-motive force of an iodine cell is about 1·4 as against ·9 of a volt for a silver chloride, we have

$$\frac{1}{3} \times \frac{\cdot 9}{1\cdot 4} = \frac{3}{14}$$

or practically one-fifth the space is required to obtain a given electro-motive force as is needed if silver chloride cells are used. If this decrease in size is at the expense of a corresponding decrease in efficiency, it might not be advisable, but such is not the case, for these cells will give, with such external resistances as are ordinarily used in test work, fully as much current as a silver chloride cell. Further, the total output of these cells is about ·2 to ·3 of an ampère hour. That of a silver chloride is ·6 to ·7; thus while the output of an iodine cell is one-third that of a silver chloride, the volume is only one-fourth as great. Carbon and zinc electrodes are employed, and the low resistance of these cells is largely due to a peculiar shape given to the carbon electrode (see *A*, *Fig. 1*). The depolarizer consists of I_2S_2, sulphur iodide, which is the only binary compound of iodine insoluble in water, with the exception of a mercury and silver salt, neither of which give a high electro-motive force. This depolarizer is put both below and above the carbon electrode, being filled in as high as the top of the lower prong of the carbon electrode (see *Fig. 1*). Now by the action of the cell a very little zinc iodide is formed, which renders the iodine in the depolarizer slightly soluble. The prongs of

the carbon, which is of a fairly porous quality, act like a wick to soak up this soluble portion and thus the electrode is kept perfectly depolarized at the exposed ends. The depolarizer, which is ground into a powder, has, moreover, a little of the paste, which is used in the cell, mixed with it, and thus a fair degree of conductivity is given to the whole mass. These two facts together cause the cell to have a very low internal resistance. Three parts by weight of iodine are used and one part of sulphur, and, as the iodine is very loosely held by the sulphur, we can say that the iodine is practically used in a free state. These cells have also been made using a depolarizer which consists of a chemical compound of HgO, mercury oxide, and iodine, with a slight excess of iodine. The formula of this compound is thought to be Hg_2O, IO_4, HgO, IO_4. This depolarizer gives an initial electro-motive force of 1·65 volts, which, however, falls in time to about 1·4 volts, where it remains nearly constant until the cell is used up. This form of depolarizer is also quite insoluble in the electrolyte used and seems to have a lower resistance when combined with a little of the paste used in the cell than the sulphur iodide. This compound does not become reduced to the metal until the cell is nearly exhausted, so there is no local action which takes place, as might be expected, between reduced globules of mercury and the carbon electrode. Tests are now being made to decide between the relative advantages of these two depolarizers. Queen & Co. have been using both types of cells for some months in adjusting all their resistance coils, and enough has already been learned, through a practical and hard test about each, to make it quite certain that they are both excellently adapted to the use to which they are put.

The paste in these cells consists of zinc oxide and aluminum chloride and water. This combination, by the formation of some aluminum hydroxide and zinc chloride, makes a smooth gelatinous paste of any desired consistency and has the important property of neutralizing the hydriodic acid that is formed in the cell, so that these batteries are quite free from gassing and will never explode. The pro-

ducts of the cell, when the circuit is closed, simply change form until the cell is used up. The following equations express the normal actions that probably take place:

(I) $Zn_x + 2\,AlCl_3 + 6\,H_2O + 3\,ZnO + [X\,(ZnCl_2)] + [X\,(Al\,(OH)_3)] + 3\,I_2S_2 + C = Zn_{x-z} + 3\,ZnCl_2 + 2\,Al\,(OH)_3 + 6\,HI + 3\,ZnO + [X\,(ZnCl_2)] + [X\,(Al\,(OH)_3)] + 3\,S_2 + C.$

(II) $6\,HI + 3\,ZnO = 3\,H_2O + 3\,ZnI_2.$

Some zinc chloride may also take part in the action when the cell is first started and later some zinc iodide. Some of the HI is also probably neutralized thus:

$$Al\,(OH)_3 + 3\,HI = AlI_3 + 3\,H_2O.$$

$AlCl_3$ is used in preference to salts of the alkali metals, for it has no dissolving action whatever on either of the depolarizers above described, which many other salts dissolve to a greater or less extent. Powdered charcoal, or preferably manganese dioxide, is also added to the paste, partly to thicken it and chiefly to improve the appearance of the cell. The fact that the zinc iodide, formed after the cell has been in action, dissolves the depolarizer to a certain extent, may be thought to be a disadvantage, but it is rather an advantage, for while it reduces the resistance of the cell, it also makes the depolarizer much more efficient in its action than it would be if absolutely insoluble. In fact, if a depolarizer is perfectly insoluble, its action must be tardy, and a cell using such will not only soon polarize, but usually have a very high resistance.

The seal in these cells is made as follows (see *Fig. 1*): The zinc electrode is held in place by a cork, over this is poured a hot mixture of gutta-percha, pitch and resin oil. This viscous material is then made secure by having poured over it a layer of the same mixture with an equal part of plaster Paris mixed through it. The terminals are both brought out of the top of the cell (see *Fig. 1*), one being of platinoid and the other of copper wire, so that the poles may be distinguished from each other.

[*To be continued.*]

BOOKS RECEIVED.

[In sending books for notice in the *Journal*, publishers are requested, for the information of the reader, as well as for their own advantage, to give the price. This announcement by title will be followed, in most cases, by a review, which will appear at the earliest opportunity.]

Infantry Drill Regulations, United States Army. Adopted October 3, 1891. New York: Army and Navy Journal and D. Appleton & Co. 1893. Price, 50 cents.

Annual Report of the Chief of the Bureau of Steam Engineering for the Year 1892. Navy Department. Washington: Government Print. 1892.

First Report of the Bureau of Mines, 1891. Printed by order of the Legislative Assembly of Ontario. Toronto: Government Print. 1892.

Leland Stanford University Publications—Studies in Electricity No. 1. Some Observations on the Conductivity of a Copper Wire in Various Dielectrics. By Fernando Sanford, M.S., Palo Alto, Cal. University Press. 1892. Price, 50 cents.

Department of the Interior. United States Geological Survey. J. W. Powell, Director. Coal. By E. W. Parker. Washington: Government Print. 1892.

Public Ledger Almanac, 1893. George W. Childs, publisher. Philadelphia.

A Memorial to Congress with Subject of a Road Department at Washington, and a Comprehensive Exhibit of Roads, their Construction and Maintenance at the World's Columbian Exposition. Boston. Albert A. Pope.

First Annual Report of the Enterprise Mining Company, September 30, 1892, with a Description of the Property. By Leo Von Rosenberg. Maps and Illustrations. New York. 1892.

Magnetic Observations at and near Albany, N. Y., between the Years 1686 and 1892. By Verplanck Colvin.

Foster Engineering Company, Newark, N. J. Catalogue.

Joseph Dixon Manufacturing Company, Newark, N. J. Catalogue.

Annuaire pour l'an 1893, publié par le Bureau des Longitudes, avec des Notices Scientifiques. Paris: Gauthier-Villars et fils. 1893. Prix, 1.50 fr.

BOOK NOTICES.

Encyclopédie Scientifique des Aides-Mémoire. Publiée sous la direction de M. H. Léauté, Membre de l'Institut. Gauthier-Villars et fils et G. Masson. (*Section de l'Ingénieur.*)

Les Textiles Végétaux; leur examen micro-chimique, par H. Lecompte. Broché 2 francs 50 c. Cartonné 3 francs.

L'Art de Chiffer et de déchiffer les dépeches secrètes, par M. le Marquis de Vairis. Br. 2.50 francs; Cart. 3 francs.

Cordierie. Cordages en chandre et en fils metalliques, par M. Alheilig. Br. 2.50 francs; Cart. 3 francs.

La Formation des Gites Metalliféres, par L de Launay. Br. 2.50 francs; Cart. 3 francs.

Essais d'Or et d'Argent, par H. Gautier. Br. 2.50 francs; Cart. 3 francs.

Les Acariens parasites, par P. Méquin. Br. 2.50 francs; Cart. 3 francs.

Canon, Torpilles et Cuirasse: leur installation a bord des batiments de combat, par A. Croneau. Br. 2.50 francs; Cart. 3 francs.

État actuel de la Marine de Guerre, par L. E. Bertin. Br. 2.50 francs; Cart. 3 francs.

Analyse des Vins, par le Dr. Magnier de la Source. Br. 2.50 francs; Cart. 3 francs.

Since our recent notice of this extremely useful series of publications now being issued from the press of Gauthier-Villars & Masson, the volumes above entitled have appeared. Each of them forms an independent volume, though forming part of a comprehensive enclopædic publication covering the entire domain of the sciences as applied to the useful arts. Each volume comprises about 200 pages of octavo size, and wherever the subject admits of it, there are illustrations. This plan of the series is admirable and each volume gives a lucid account of the present state of the art to which it relates.

W.

Logarithmic Tables. By Prof. George William Jones, of Cornell University. Fourth Edition. London: MacMillan & Co. Ithaca, N. Y.: Geo. W. Jones. 1893. $1.

With this new edition Professor Jones' well-known and favorably-known tables appear in a form entirely new, and in most, or in all respects, greatly improved.

The most striking innovation is the material increase in the size of the pages without corresponding enlargement of the type used.

At the same time the very important improvement has been made of placing only fifty lines on a page in the tables of logarithms, instead of sixty, as heretofore, thus bringing each hundred of numbers upon two facing pages.

These changes give, of course, a much more open page, and will, we think, render the use of the tables even less trying to the eyes than before.

We fail to see the advantage of the abandonment of the use of bold-face type in the head-lines and foot-lines and in the side columns.

The volume has grown from 96 to 120 pages. Among the more important additions are tables of four-place logarithms, of four-place trigonometric functions, of prime and composite numbers, of roots and of powers

and of reciprocals. Several of the old tables now appear in greatly extended form.

As a guarantee of correctness, notwithstanding the resetting of the entire work which this edition involves, the author-publisher continues his offer of $1 for the first notice of any error.

The tables are a model of typographical excellence, and the profits at the very low price named must be near the vanishing point. T.

Manual of Qualitative Blow-pipe Analysis, and Determinative Mineralogy. By F. M. Endlich, Ph.D. New York: The Scientific Publishing Company. 1892.

The author of this work was a pupil of Richter. He has evidently given this particular branch of qualitative analysis much study, and writes as one who is in love with his work. As a result his book is comprehensive and thorough. It contains all of the most recently discovered reactions that are of value, and gives considerable space to the behavior before the blow-pipe of the rarer elements. The determinative tables are very complete, occupying over 130 pages, about one-third of the entire book.

The book needs an index to minerals, since without it, the student, in using the tables, is obliged to use the deductive method exclusively.

On the front of p. 308, a method of detecting potash in muscovite is given that will show potash whether it be present or not. P.

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, March 15, 1893.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 15, 1893

MR. H. R. HEYL, Chairman *pro tem.*

Present, eighty-nine members and six visitors.

Additions to membership since last report, eleven.

The Secretary reported the resignation of Messrs. Philip Pistor and W. M. McAllister from the Committee on Science and the Arts.

On motion, it was decided to fill the vacancies at the next stated meeting.

Mr. James M. Price read a paper on "The Price Metallic Ties," illustrating the subject by the exhibition of diagrams and specimens.

Mr. Alex. E. Outerbridge, Jr., read a paper on "The Modern Traveling Crane," illustrated by several lantern views. Referred for publication.

On account of the lateness of the hour, it was decided to postpone until the next stated meeting the communication of Mr. John M. Hartman, on "Ancient Egyptian Architecture."

For the same reason, the Secretary's report was deferred.

Adjourned. WM. H. WAHL, *Secretary.*